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PROCEEDINGS

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1909, pp. 1-544.

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OF THE
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OF THE
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1909.

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PROCEEDINGS

OF THE

GENERAL MEETINGS FOR SCIENTIFIC BUSINESS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.

(January to April, 1909.)



January 12, 1909.

Prof. J. ROSE BRADFORD, M.D., D.Sc., F.R.S., Vice-President,
in the Chair.

The Secretary read the following report on the additions made to the Society's Menagerie during the month of December 1908:—

The number of registered additions to the Society's Menagerie during the month of December last was 57. Of these 36 were acquired by presentation, 8 by purchase, 7 were received on deposit, 2 by exchange, and 4 were born in the Gardens. The number of departures during the same period, by death and removals, was 212.

Amongst the additions special attention may be directed to:—

A Brown Bear (*Ursus arctos*), from Russia, presented by G. Cecil Whitaker, Esq., on December 8th.

Two Mole Rats (*Georychus hottentottus*), new to the collection, from Mashonaland, presented by J. folliott Darling, Esq., F.Z.S., on December 9th.

Two Labrador Jays (*Perisoreus atricapillus*), from Labrador, presented by the Rev. W. W. Perrett on December 14th.

One Yellow-billed Sheathbill (*Chionis alba*), from the Falkland Islands, presented by F. W. Tode, Esq., on December 14th.



Dr. H. G. Plimmer, F.L.S., F.Z.S., Pathologist to the Society,
exhibited the stomach of a Boa suffering from gastritis, and the
Proc. Zool. Soc.—1909, No. I.

stomach and intestines of a Cobra suffering from gastro-enteritis, and made the following remarks:—

“These specimens are shown in order to call attention to the condition of inflammation of the stomach and intestines in snakes from the Society’s Collection. Out of 160 cases examined during the last year by far the larger number showed this condition in varying degrees; and that is after excluding those cases due to the direct irritation of worms which had caused ulceration or perforation.

“Of course there are many causes of inflammatory conditions of the stomach and intestines, but it would appear, from the large percentage of cases showing this condition, that there must be some common cause, and as the present method of feeding the snakes is an unphysiological one, it might be worth while to consider whether it may not be the cause of the large mortality from these inflammatory conditions of the alimentary tract.”

The following papers were read:—

1. Observations on the Flagellates Parasitic in the Blood of Freshwater Fishes. By Prof. E. A. MINCHIN, M.A., V.P.Z.S.

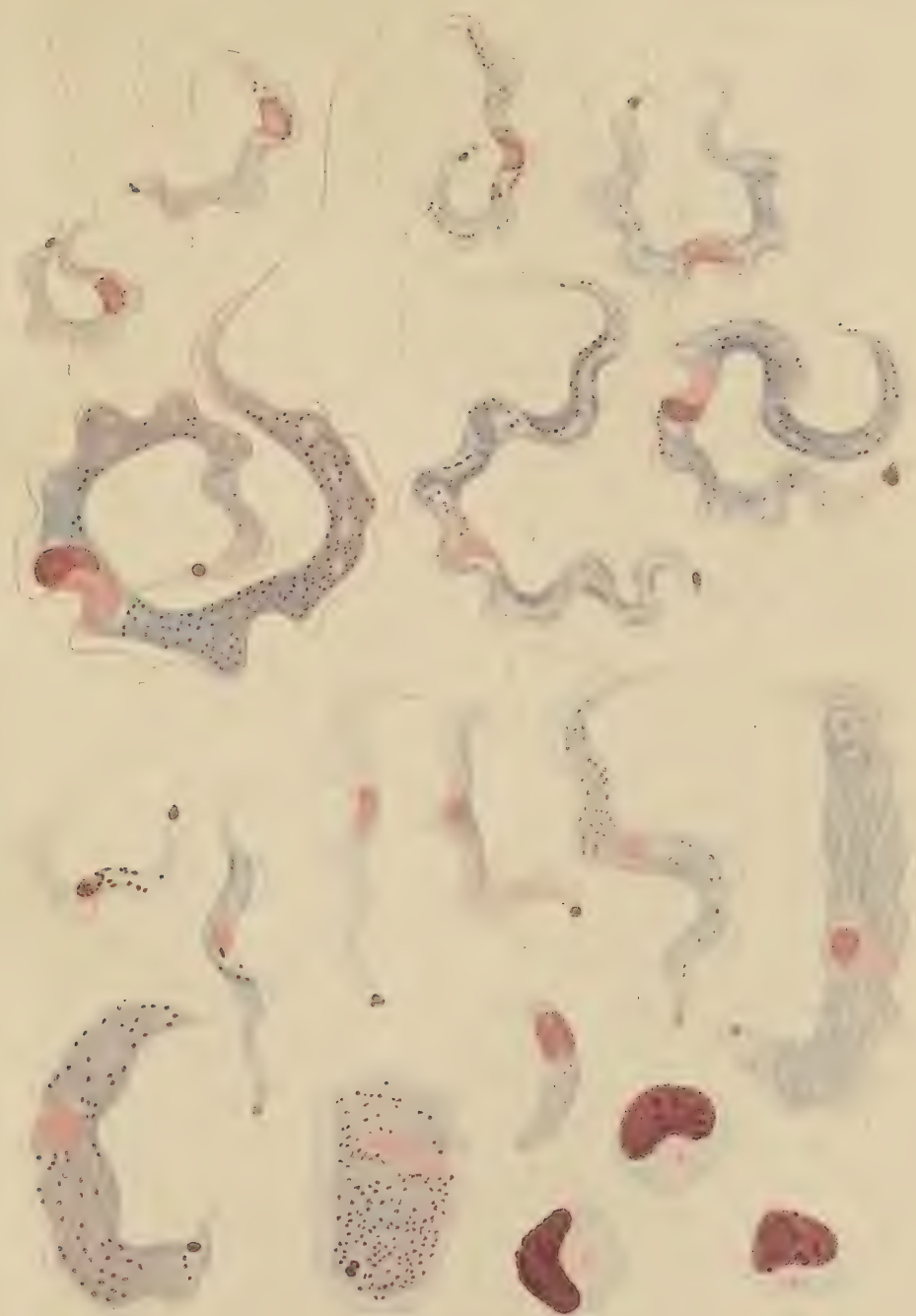
[Received December 23, 1908.]

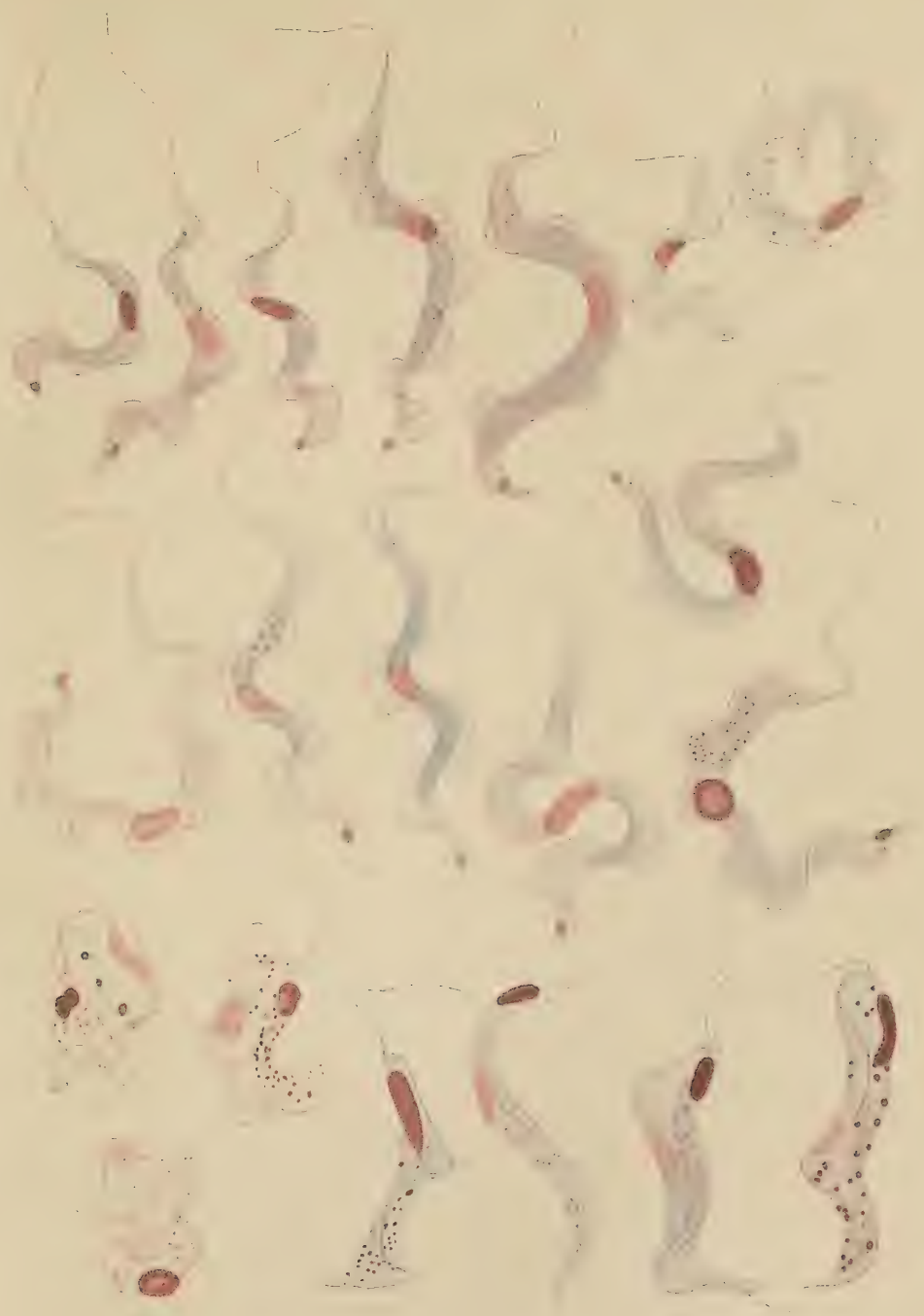
(Plates I.–V.*)

Introductory.

The trypanosomes and trypanoplasms of freshwater fishes have been studied by a number of naturalists abroad, and have been the subject of several important memoirs, more especially by Laveran & Mesnil, Léger, and Brumpt in France, and by Keysselitz in Germany. In this country, however, little attention has been paid to them. I was therefore glad to avail myself of the exceptional opportunities offered by the Sutton Broad Laboratory, to study the parasites of the fishes in the Norfolk Broad. I desire to take this opportunity of expressing my warmest thanks to my friends Messrs. Eustace and Robert Gurney for their kindness in putting at my disposal the resources of their picturesque and well-equipped laboratory, and for much help during my stay there. I spent portions of my summer vacations at the laboratory, about three weeks in August and September 1907, and five weeks in the same months in 1908, and during these periods I occupied myself almost entirely with these parasites. Although I have only touched the fringe of the question so far, and there is still everything to be discovered and worked out concerning the all-important

* For explanation of the Plates see p. 29.





M. R. ad nat. del.

Lith. Anst. v. E. A. Fuchs Leipzig.

PLATE I. TRYPANOPLASMS OF PIKE.
TRYPANOPLASMS OF PIKE.



M R ad nat del.

Lith Anst. v. E. A. Fuchs, Leipzig.

TRYPANOPLASMS OF TENCH, BREEM AND RUDD.

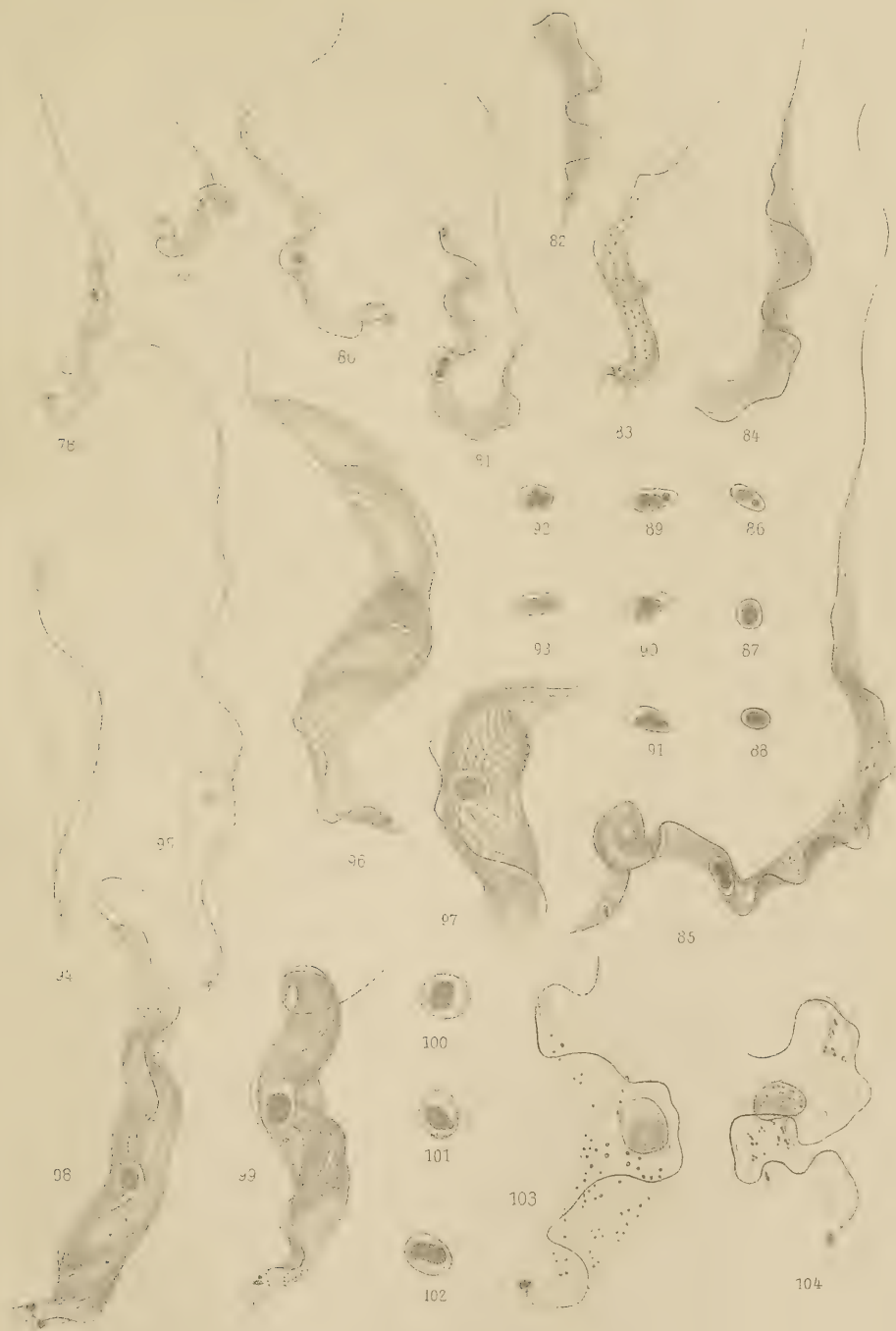




E. A. M. & M. R. ad. nat. del.

Life. Anst. v. E. A. Funke, Leipzig.

TRYPANOPASMS OF PIKE, TENCH, AND BREAM.
TRYPANOSOMES OF TENCH



question of the transmission of these parasites, I thought it worth while to publish my investigations at the point they have reached, leaving the subject in a condition in which it can be taken up again and carried further by myself or by anyone else working in the same region.

Methods and Technique.

In examining the blood of fishes for the parasites, it is not difficult, when dealing with a fish of fair size, to take the blood from the gills of the fish without materially injuring it. There is always a risk, however, that the blood obtained in this way may contain a certain amount of water mixed with it. To obtain good smears I found it best to sacrifice the fish. Having killed it by a smart blow on the head with a blunt instrument (best a stout rod of hard wood) I opened up the pericardial region and took the blood from the heart by means of a fine capillary glass tube, thrust through the wall of the heart; the blood was allowed to run up into it, and then blown on to the slide or coverslip. The whole process has to be done quickly, since fish-blood coagulates very rapidly. Fish which are used in this way for making blood-smears suffer no detriment in respect to their culinary properties and need not be wasted.

Much has been written lately about methods of fixation of these blood-parasites, especially with regard to the procedure most in vogue, of drying smears of the blood. That the process of drying affects the minute structural details cannot be doubted and can be demonstrated easily. It should, however, be pointed out that the effects of drying, so far as trypanosomes are concerned, differ greatly according as the drying is done before, or after, fixation with some histological reagent. Very instructive in this respect are the species of the genus *Trypanoplasma*. Their soft protoplasmic bodies become greatly deformed if dried before fixation; in this respect they contrast strongly with the species of *Trypanosoma*. In some fishes, for example the pike, tench, and bream, it is common to find both trypanosomes and trypanoplasms in the blood; in smears dried before fixation, the trypanosomes may be found quite satisfactory in form and general structure, while the trypanoplasms side by side with them are deformed almost beyond recognition; compare figs. 25, 26, and 39, showing trypanosomes and trypanoplasms of the pike, from the same slide; figs. 32, 53, 54, showing similar conditions in the blood of the bream. In some cases, however, a trypanoplasma may, apparently, flatten down evenly and thus give a fairly reliable representation of its natural form and structure (compare figs. 37 and 38, from the same slide); such cases, however, are in my opinion to be regarded as accidental and exceptional, and the rule is that trypanoplasms when dried become much deformed. It is therefore a matter of astonishment to me that Keysselitz should have relied so much on material dried before fixation for his

lengthy and detailed study of the life-history of *Trypanoplasma cyprini* ("borreli"). It is, perhaps, for this reason that Keysselitz was unable to distinguish more than one species of *Trypanoplasma*.

The deformation subsequent on drying is entirely avoided if the smear be placed as quickly as possible, immediately after smearing and before any appreciable amount of drying has taken place, into a stoppered tube or bottle containing a few drops of osmic acid, 4% solution. It should be exposed to the vapour for 30-60 seconds, and then transferred, with or without drying, to absolute alcohol. After the fixation with osmic vapour the drying does not deform even the trypanoplasms, and the natural form, size, and appearance of these flagellates are, in my opinion, better preserved by this method than by any other. The osmic-fixed smears stain well with Giemsa's stain, but are apt to stain rather too darkly and, in the case of large fleshy forms of the parasites, to become very opaque. Speaking generally, they should be stained for a much shorter time than the preparations dried off before fixation.

The weak point of the preparations stained by the Romanowsky method, whether dried before or after fixation, or not dried at any time, lies in its effects on the nuclear apparatus. I hope to discuss this point in greater detail in a memoir which I am preparing on the structure of *Trypanosoma lewisi*. I will say here only that the Romanowsky stain, in its various modifications, gives results with regard to nuclear structure which are not capable of uniform interpretation, and which, in my opinion, are untrue and misleading. I believe the defects of the stain to be due principally to the fact that the red dye or dyes in the stain are precipitated not only in, but around, certain objects in the preparations; with the result that the kintetonucleus, for example, appears many times its real size, while in the trophonucleus minute, almost ultra-microscopic granules become enlarged to coarse granules obscuring the true structure. This effect is not due to the drying, since it is to be observed in preparations stained by the Romanowsky method and mounted in Canada balsam without being dried at any stage of the process. I believe, however, that the process of drying, whether before or after fixation, may and does add greatly to the falsity of the nuclear results obtained by the stain. While osmic vapour fixes very perfectly the cytoplasmic portions of the body, it apparently leaves the nuclear constituents unfixed and in a fluid condition. Hence, while the general structure of the body is very perfectly preserved, even when dried, after osmic fixation, the nucleus remains in a fluid state and liable to deformation. That, at least, is the impression which a comparison of different methods gives me.

For interpretation of the results obtained by the Romanowsky stain, it is very instructive to compare the totally different results obtained by staining the same objects with Heidenhain's iron-hæmatoxylin. For this it is necessary, however, that the smears should be suitably fixed and that they should have never been

dried. I have tried various fixatives and get the best results with sublimate-acetic (HgCl_2 saturated in water 95 volumes, glacial acetic 5 volumes), Schaudinn's fluid (HgCl_2 saturated in water 2 volumes, absolute alcohol 1 volume, with addition of a few drops of glacial acetic), and Mann's picrocorrosive-formol solution. The first two fixatives may be used directly on the wet smears, or with previous exposure to osmic vapour for a short time. I find it useless, however, to fix the smears on slides; the reason being that it is impossible, or at least very difficult, to put them into the fixatives without making them dive in with one end foremost, a process which causes distortion in the wet and still unfixed elements of the smear. Satisfactory preparations can only be obtained by these methods of fixation, by making the smear on a coverslip and dropping it at once with the smear downwards into the fixative. I hold the coverslip with the fingers of my left hand, and a glass rod in my right hand; a drop of blood is placed by an assistant on the coverslip; I then smear it out immediately with the glass rod and drop it instantly into the fixative. The whole process can be done most expeditiously, and with much less risk of partial drying than when dealing with slides.

In staining trypanosomes with iron-hæmatoxylin, I find it best to let the mordant and stain act for a long time. The objects are first left in the iron-alum solution ($3\frac{1}{2}\%$) over night; they are then, after brief and rapid washing with distilled water, transferred to the hæmatoxylin solution ($\frac{1}{2}\%$) for at least 24 hours. The whole art of the process lies in the differentiation and extraction of the stain. My method is to put the coverslip into the iron-alum until colour is seen to be coming out; then the coverslip is dipped into tap-water to stop the extraction of the stain, and examined with moderate magnification (Zeiss Oc. 4, Obj. D). If the karyosome can be seen sharply and clearly in a trypanosome, the extraction is sufficient; if not, the coverslip is put into iron-alum again for a short time. Usually I do several smears of each sample of blood with different degrees of extraction of the stain. In most smears there are also thicker and thinner portions, and it is found that in thicker portions of the smear the stain is not so quickly extracted from the trypanosomes as in the thinner portions. Different degrees of extraction of the hæmatoxylin have their uses in showing up different points of structure. When the trypanosomes first come out of the stain they have an even, opaque black colour. I find that usually the stain is extracted first from the cytoplasm generally, then from the myonemes; next from the coarse granulations of the cytoplasm; next from the flagella and the blepharoplasts; next from the karyosome, and last of all from the kintonucleus which appears to give up the colour at its periphery first. There are exceptions, however, to this order, for in some trypanoplasms (e. g. *T. gurneyorum*) the cytoplasmic granules retain the stain as long as the karyosome. In one of my preparations which was under-extracted, I found that the trypanosomes and trypanoplasms showed their form and

the flagella very sharply, but were too opaque for internal structure; I therefore had the parasites drawn in outline with the camera lucida, then unmounted the coverslip, extracted more of the stain, and, after mounting it again, added the details of minute structure to the drawings already made.

With use of iron-hæmatoxylin in never-dried preparations suitably fixed, absolutely uniform results are obtained with regard to the nuclear structure. When two such staining methods as the Romanowsky stain and the Heidenhain stain give conflicting results in matters of nuclear detail, no one with any knowledge of cytological methods would hesitate, I think, to regard as more reliable the evidence yielded by the Heidenhain stain.

The figures illustrating this memoir were drawn with the camera lucida to a magnification of 2000 linear, with the exception of the sketches drawn from living trypanosomes (figs. 77, 94, 95). The majority of the drawings were executed by my assistant Miss Rhodes, to whom I desire to express my thanks for her skilled help in this work.

General Remarks on the Trypanosomes and Trypanoplasms of Fishes.

It would, perhaps, be more logical if the general account of these parasites came after the detailed descriptions of the species, since the conclusions at which I have arrived are founded on the data which are set forth in the special descriptions. But to many the general summary of results that is given here will be of greater interest than the, perhaps, rather wearisome special details, which therefore I relegate to second place, for purposes of reference for those specially interested.

From a study of the trypanosomes of fishes in the fresh, living condition in the blood, I have come to the conclusion that there are two types of movement: a conclusion which may perhaps be true of trypanosomes universally. Sometimes they may be seen to move in a definite direction; at other times they are seen to be twisting about in one spot without moving from it. I term these two types of movement travelling and wriggling respectively. They travel usually with the flagellum forwards; in the trypanosome of the eel I have observed progression of this type only. Some trypanosomes, however, can be seen to travel occasionally with the flagellum directed backwards; progression in this manner appears to me to occur chiefly when the trypanosome is forcing its way through corpuscles, and never when its path is unobstructed. In either case, however, progression appears to be effected chiefly by flexions of the whole body and by rippling movements of the undulating membrane, and scarcely at all by means of the free flagellum.

In wriggling movements the trypanosome simply twists over and over in S-like curves in one spot, and often appears as if tied in a knot; this is what I understand Laveran and Mesnil to mean

by the expression "pelotonné." The object of these movements is probably simply to increase the animal's power of absorbing nutriment &c. from the surrounding medium, by incessantly changing the surface of contact between the body and the blood-plasma, just as a *Tubifex* in the mud wriggles incessantly in order to bring the surface of the body into contact with fresh water and oxygen. I think it highly probable that when these parasites are being carried round passively in the circulation they perform wriggling movements only, having no occasion to travel. On the slide, however, they are seen sometimes to travel, sometimes to wriggle; but when they become moribund they only wriggle.

Trypanoplasma, so far as I have observed, travels always with the anterior free flagellum forwards; I have never seen it go with the posterior flagellum, that is to say the flagellum which runs along the edge of the undulating membrane, directed forwards. If the kintetonuclear extremities of *Trypanosoma* and *Trypanoplasma* are to be considered homologous, then the direction in which the former usually travels is the opposite to that in which the latter invariably progresses. I have not observed in *Trypanoplasma* anything comparable to the wriggling movements of *Trypanosoma*; the former genus has the body relatively much shorter and less flexible. It can be observed frequently, however, that a *Trypanoplasma* when travelling in a certain direction will quite suddenly bend over on itself and travel in a direction more or less the opposite to that which it took formerly.

A remarkable feature of some trypanosomes and trypanoplasms of fish is the great disparity in size between different individuals in the same blood. This point has already been noticed by previous observers with regard to the trypanosomes of the pike and the eel, both of which have been divided, each into two varieties, distinguished as var. *parva* and var. *magna* respectively. In the five fish-trypanosomes examined by me, I find the state of things different in different species. In the trypanosomes of the bream and the tench, which are perhaps one and the same species (figs. 27-32), I could not find any variation in size sufficiently well marked to be characterized as true dimorphism; but my material of these two forms is not so abundant as in other cases. In the trypanosome of the pike (*T. remaki*, figs. 20-26) I found the well-marked dimorphism described by Laveran and Mesnil, and though the two forms *parva* and *magna* each vary slightly in size and other characters, they were nevertheless easily distinguished, and no forms could be found transitional between them. In the trypanosome of the perch (*T. percae*, figs. 8-14) I found three principal types—small slender forms, large stout forms, and intermediate forms. The small forms and the intermediate forms are connected by transitions (figs. 10, 11), but the stout forms stand rather apart, owing to the shortness of the free flagellum (figs. 13, 14). Finally in the eel, I found every possible gradation between the smallest and the largest forms (figs. 1-7); there is a very great difference in size between the two extremes, but the absence of a dividing line

between them makes it difficult, if not impossible, to distinguish the varieties *parva* and *magna*.

The significance of this dimorphism or polymorphism is not clear, and must be explained from the life-history. Two possible explanations present themselves: first, that the difference between small and large forms is one of growth and development; secondly, that it is a manifestation of sexual differences, small male and large female forms being differentiated from an indifferent or intermediate form. The trypanosomes of the pike and the perch rather favour the sexual hypothesis, but the state of affairs in the eel-trypanosome strongly suggests stages of growth merely. Certain facts that I have observed in the perch have awakened in me the suspicion that these fish-trypanosomes have some form of multiplication in the internal organs of the fish, and that fission of the type familiar in other trypanosomes perhaps only occurs after a new infection, just as in *Trypanosoma lewisi* fission is only found in the first week or ten days after inoculation. Fission has very seldom been seen in fish-trypanosomes; so far as I am aware, it has only been seen in *T. remaki* immediately after inoculation into a pike (Laveran and Mesnil) and in *T. granulorum* in cultures *in vitro* (Lebailly, França). The absence of fission-stages in the blood of fish infected naturally is very striking. The subject is one requiring renewed investigation.

In the trypanoplasms of the tench (figs. 40-43) and pike (figs. 33-37, 56) I have also observed smaller and larger forms, sharply distinct not only in size but even in nuclear structure; the large forms are much less common than the smaller "ordinary" forms, and both types are divisible into two categories by differences in the nuclear apparatus, especially the kinetonucleus. According to Keysseltz the large forms are gametes destined to conjugate in the intestine of the leech; those with larger kinetonuclei are regarded by him as gametes of male character, while the forms with smaller kinetonuclei are regarded as female. In one of the ordinary forms of the trypanoplasm of the pike I have seen the only example that has come under my notice, of what is apparently nuclear division (fig. 62).

It is a moot point, how far different species of trypanosomes can be distinguished by morphological characters. As I have already said, the trypanosomes of the five species of fish studied by me belong, in my opinion, to four species, namely (1) the trypanosomes of the bream and tench, (2) of the pike, (3) of the perch, (4) of the eel. Each of these four putative species can be easily distinguished from the other three by its structural characters, considered as a whole; I need only refer to my figures. There is, however, always the possibility to be borne in mind that one and the same species of trypanosome, when inoculated into distinct species of fish, might vary in character in response to differences in the environment; this is a point on which experimental evidence is needed. The trypanoplasms of the tench, bream, and pike seem to me also to constitute three well-

characterized morphological species, each quite distinct from the only specimen of *T. borreli* of the rudd that I have seen.

Considering the great variability in size of these parasites, it is remarkable that so many authors should base their specific descriptions so largely on measurements. A naturalist, for instance, of the attainments and experience of my friend M. Brumpt (to whom I owe my first lesson in the art of staining trypanosomes in blood-films) can hardly have thought such measurements to be of any real validity as specific characters.

In considering the minute structure of these parasites we may begin with the nuclear apparatus. As I have stated above, the use of iron-hæmatoxylin as a stain permits of a uniform interpretation of the appearances; and I think it is a very important point, that it is possible to give in general terms a description of the nuclear apparatus which will apply to trypanosomes and trypanoplasms alike. In both cases we find a kinetonucleus and a trophonucleus, the first named being relatively very large in the trypanoplasms, small in the trypanosomes. Near the kinetonucleus are found the minute blepharoplasts or basal granules of the flagella, two in *Trypanoplasma*, one in *Trypanosoma**.

The kinetonucleus in both cases appears as a dense body stained a uniform deep black after iron-hæmatoxylin. I have not been able to detect any structure in it. When the stain is over-extracted it appears to come first out of the periphery of the nucleus and last of all out of the central part, but this appears to me to be merely the expression of the dense texture of the kinetonucleus, and not to indicate any structural difference between central and peripheral regions. After the Romanowsky stain the kinetonucleus appears very much larger than it does after iron-hæmatoxylin; it may be four or five times as large (compare figs. 33-36 and 57-64; 40-43 and 66-72; 1-7 and 78-85, &c.). As I have stated above, I believe this result to be due to the fact that the stain forms a deposit round it. With iron-hæmatoxylin the size of the kinetonucleus is quite uniform if the stain be not over-extracted, in which case also the true size is indicated by a clear space surrounding the central portion stained black.

The blepharoplasts appear usually as very minute dots, scarcely thicker than the flagellum, after iron-hæmatoxylin. There appears to be a band of fibril connecting the kinetonucleus and the blepharoplasts, which is shown by iron-hæmatoxylin, at a certain degree of extraction (fig. 98); it stains much less deeply than the kinetonucleus. After the Romanowsky stain the blepharoplasts often appear much larger and may be conspicuous; hence this stain is useful for demonstrating their existence, although it

* I adhere, in my descriptions of the structure of these parasites, to the terminology of the organs suggested by me in the 'Quarterly Journal of Microscopical Science,' lii. pp. 171-174, text-fig. A; with the difference that I employ the term "karyosome" for the intranuclear body there termed "centrosome." To judge by its behaviour during nuclear division, the karyosome of a trypanosome probably contains a true centrosome or "centriole."

does not exhibit them in their true proportions. The flagella also share in the general enlargement after the Romanowsky stain, and appear very much thicker than they do after iron-hæmatoxylin, which shows them as very delicate filaments; they give up the stain more readily than do the true chromatic structures.

The trophonucleus is very different in its structure from the kinetonucleus. After iron-hæmatoxylin (Plates IV. and V.) it appears as a clear space, oval or round, limited by a faint but quite definite membrane, which, when carefully examined, appears granular and uneven in thickness, and is probably composed of granules of chromatin connected together; it is therefore not a true nuclear membrane, in the sense in which the term is used for Metazoan nuclei. The trophonuclear membrane is much less distinct in *Trypanoplasma* than in *Trypanosoma*; a difference perhaps largely due to its being obscured in the former genus by the numerous and deeply staining cytoplasmic granulations. In the space enclosed by the nuclear membrane lie one or more karyosomes, rounded bodies often very large, and staining very deeply with iron-hæmatoxylin. The karyosomes appear to me to be simply masses of chromatin; they retain the stain very tenaciously. Typically there is a single karyosome placed more or less centrally, but their size, number, and arrangement vary greatly, as will be seen by reference to the figures and special descriptions of the species. In the space between the karyosome or karyosomes and the nuclear membrane there are found minute chromatin granules, often disposed so as to leave a clear space round the karyosome; the granules themselves are often so minute as to be scarcely visible.

Where, it may be asked, are the definite chromosomes, eight in number, surrounding the karyosome, so often described by Schaudinn, Léger, Keysseltz and others? Where indeed! I can but describe what I have seen, and I have never seen, after iron-hæmatoxylin, more than I have described above. Possibly the Schaudinnian chromosomes make their appearance at certain stages of the development or phases of the life-history. I can only say that they have never revealed themselves to me in any of my preparations. After the Romanowsky stain, it is true, a great variety of appearances can be seen, impossible to interpret in a uniform manner: sometimes the whole trophonucleus appears an even red mass, sometimes it shows coarse granulations disposed in various ways; in all cases its great difference in size, structure, and appearance from what is seen in the iron-hæmatoxylin preparations is quite bewildering. I have put forward above, in the section dealing with technique, what I believe to be the explanation of this. I hope to discuss the whole question much more fully in dealing with *Trypanosoma lewisi* elsewhere.

Lühe has given* two figures of the trypanoplasm of the carp stained with iron-hæmatoxylin. He figures the trophonucleus as

* In Mense's 'Handbuch der Tropenkrankheiten,' iii. p. 83, fig. 5.

a simple black rounded mass. I am of opinion that what he has figured is simply the karyosome, and that the peripheral portion of the nucleus is not shown. The nuclear space and membrane are often not at all distinct, as I have said above, and I have often seen the trophonucleus appearing just as Lühe has figured it.

In the cytoplasm there are commonly numerous coarse granulations, which stain like chromatin after Romanowsky, but I feel strong doubts as to their being chromidial in nature. After iron-haematoxylin I found that the granules gave up the stain much more readily than the true chromatic structures, in the trypanosomes; but in the trypanoplasm of the pike they held the stain very tenaciously. Their true nature could only be determined by the development.

In the trypanosomes of the perch (figs. 96, 97) and eel (fig. 84) I was able to obtain preparations showing the myonemes after the iron-haematoxylin stain. I have not been able to see myonemes in any trypanoplasm. I am convinced that to see the myonemes it is necessary to get just the right degree of extraction of the stain; a shade less extraction, and the myonemes are obscured by the darkness of the cytoplasm; a shade more, and the myonemes give up the stain. The darkly staining, opaque cytoplasm of the trypanoplasms probably makes it much more difficult to render visible the myonemes than in the case of the trypanosomes. From my preparations the myonemes appear to be about eight in number in the trypanosome of the eel, but more than that in the trypanosome of the perch. I have never been able to make them out with certainty after the Romanowsky stain.

With regard to the question of the transmission of the trypanosomes and trypanoplasms of fishes, on which much light has been thrown by Brumpt and Keysseltz, I have only a few negative results to record. I found leeches very seldom on the fish caught by me; only once on a rudd, and once on a perch, a *Piscicola* was found attached. On the other hand almost every fish, of whatever species, had *Argulus* attached to it when caught; sometimes there would be five or six *Arguli* on one fish. *Argulus* is stated in all the memoirs and text-books dealing with it to feed on the blood of fishes; it is an active swimmer, and readily leaves one fish and attaches itself to another. It seemed to me therefore that *Argulus* was a creature admirably suited by its habits to disseminate blood-parasites, either by the direct mechanical method, or with a cycle of development. Moreover, *Argulus* is beautifully transparent, and everything in its interior can be seen in the living animal under the microscope; it is easy to focus its blood-corpuscles flowing through the heart and circulating in all parts of its body-cavity, or to see all the contents of its digestive tract, without injuring the beast in any way. It would be quite an ideal form in which to study the development and transmission of hæmoflagellates. I took numerous *Arguli*, kept them hungry for

a day or two, and then put them into bell-jar aquaria containing various fishes. As a rule the *Arguli* attached themselves at once to the fish very firmly. After leaving them for varying periods I removed the *Arguli* and examined them, first living and uninjured under the microscope, and afterwards dissected in salt-solution and examined fresh. Although the fishes on which the *Arguli* fed contained trypanosomes or trypanoplasms in all cases, I never found a flagellate of any sort or description in the *Arguli*, however the experiment was varied; and, moreover, I never in any case found the *Arguli* to contain blood-corpuscles. It might be supposed that an animal so transparent as *Argulus* would show the effects of a meal of blood by a change of colour visible to the naked eye; but in no case could a change of colour be discerned by any optical means whatsoever. I very much doubt, therefore, if *Argulus* feeds on blood, or at least on blood-corpuscles. Very possibly only fluid plasma or lymph can pass the very minute terminal aperture of its proboscis.

My experiments with leeches were greatly hampered by the fact, in the first place, that I can lay claim to no special knowledge of the Hirudinea, and secondly, that no general monograph of this group was accessible to me of later date than that of Moquin-Tandon (1846). It would be a great boon to those studying these parasites if a more recent monograph or handbook were in existence. It is not every student of hæmoflagellates who is at the same time, like M. Brumpt, a first-class expert on leeches. I obtained a few specimens of *Piscicola*, but found nothing in them of flagellate nature. I put a *Piscicola* in an aquarium in company with a perch; the leech took no notice of the fish, nor the fish of the leech. After some days I removed the leech, dissected it, and found nothing in it. I also caught in the Broad some other leeches, which I could not identify accurately, and put them in with perch; in all cases the leeches vanished completely, and were apparently eaten by the fish. *Voilà tout!*

I can therefore make no positive additions to the transmission-question, but I hope to return again to this point when opportunity offers itself.

Description of the Species.

1. TRYPANOSOMA PERCÆ Brumpt. (Plate I. figs. 8-15; Plate V. figs. 94-104.)

Brumpt (CR. Soc. Biol. lx. 1906, p. 161) describes this species as follows:—" Dans le sang de la Perche (*Perca fluviatilis*). Ce parasite mesure 57μ de longueur totale, dont 16μ pour le flagelle, et 3μ de large. Le blépharoplaste est à $1\mu.5$ de l'extrémité postérieure. Le noyau se trouve à égale distance de la racine du flagelle et de la partie postérieure."

I identify the trypanosomes found by me in the Perch as *T. perche* Brumpt solely on the ground of occurrence, since Brumpt's description might apply to almost any trypanosome, and fails to

note any of the peculiarities of the trypanosome of the perch, or to take into account its variations of size and structure.

Trypanosomes were found more or less abundantly in almost all the perch examined by me. In a few of these fish none was seen, or they were found only after more prolonged searching; as a rule, however, they were found at once and were present in considerable numbers. If a fish was not well infected, I did not trouble to make smears of it or to examine it further. Hence the few cases in which I did not find trypanosomes were probably cases in which careful search would have revealed the presence of the parasites in scanty numbers. I doubt if any of the perch were really entirely free from them. From the perch I examined, I gained the impression that the trypanosomes were rather more abundant in small or medium-sized fishes than in those of the largest size. I did not find trypanoplasms in any of the perch examined*.

Examination of the blood freshly drawn from the perch showed that the trypanosomes differed considerably in size. They may be divided, speaking generally, into large and small forms. The large forms were much the most abundant; the small forms were very scarce. The large forms when seen living (figs. 94, 95) appeared stout and sluggish, as a rule of considerable size, but showing marked variations in this respect, some being smaller and more active. They wriggle incessantly but do not travel much. The body is spindle-shaped; one end, which bears the flagellum, is greatly attenuated and sharply pointed; the other is also drawn out, but is much less attenuated and appears to end more bluntly. At the blunt end a distinct, very refringent dot could always be seen, doubtless representing the kinetonucleus; it appeared light at a high focus, black at a low focus. Sometimes two small dots could be seen (fig. 94), in which case the second was probably the blepharoplast. The nucleus could be seen distinctly as a rounded clear space in which the karyosome appeared as a darker spot, not very refringent. A short way behind the nucleus there was seen in some specimens a distinct dot or grain, much more refringent than the karyosome, and apparently lodged in a clear space or vacuole (fig. 95); this body was not always seen. The undulating membrane and flagellum could be clearly distinguished, especially when the parasites were moribund and becoming slower in their movements, after being under observation for some hours.

The trypanosomes show a great tendency in the living state to twist and roll themselves up, in a way that calls to mind a snake of stout build, such as a python. Their movements were of two kinds, which have been distinguished above as wriggling and travelling movements respectively. When wriggling they simply twist over and over, throwing themselves into S-like curves, without changing their place. When travelling the body is

* Keysselitz (Arch. Protist. vii. 1906, pp. 2, 3) records the occurrence of both trypanosomes and trypanoplasms in *Perca fluviatilis*.

stretched out, with the undulating membrane rippling actively, the undulations commencing at the flagellar extremity and passing backwards down the body. They travel usually with the flagellum forwards and the body straightened out; the movement is effected apparently, chiefly by the undulating membrane; the blunter posterior prolongation of the body meanwhile performs curling or wagging movements which appear to be of a passive kind, the result of the movements of the undulating membrane. I saw a trypanosome, travelling in this manner on a slide under a coverslip, approach and go straight through a closely packed mass of blood-corpuscles, flagellum foremost and body straight. The same trypanosome was seen also to reverse its movement and move with flagellum directed backwards; the blunter extremity of the body, now foremost, performed movements which appeared to be active in nature, and to assist the body in penetrating forwards. This was observed also in other cases. Trypanosomes which were travelling actively were observed to come to a stand-still and perform simply wriggling movements; conversely, trypanosomes which have been wriggling for some time may start off and begin travelling.

The smaller forms were very similar to the large forms in their general appearance and the character of their movements, and only differed in their small size, pronounced slenderness, and much greater activity and rapidity of movement.

The trypanosome of the perch does not seem to possess the extraordinary vitality of *T. granulosum* of the eel. I found that the trypanosomes did not live more than a few hours *in vitro*. I made an observation, however, relating to their vital powers which perhaps is not without interest. From a perch which was very well infected, and from which I made a number of smears (fig. 11 was taken from this fish) I took three drops of blood; one drop was simply placed on a clean slide and covered with a cover-glass; the second drop was placed on a slide and mixed with a drop of Laveran's salt-citrate solution, and then covered; the third drop was put on a slide and mixed with a drop of tap-water, and then covered. The three drops were studied from time to time. In the drop mixed with water the trypanosomes showed greatly increased activity after about an hour, travelling with great rapidity in the hæmolyzed blood; after four hours they were still very active, but not quite so active as they had been earlier. After five hours I slipped off the coverslip, smeared out the blood, dried it, fixed it with absolute alcohol, and stained it with Giemsa's stain. The trypanosomes stained well and appear perfectly normal. In the drop of blood mixed with salt-citrate solution the trypanosomes also remained active but some of them were changed in form after four hours, the body becoming pear-shaped, with most of its substance aggregated at the hinder end. In some cases the trypanosomes appeared as if anchored by the hinder end; the anterior end of the body lashed round in all directions, but seemed unable to move the inert posterior

mass. After about five hours I slipped off this coverslip also and made a preparation of the blood, but it only shows trypanosomes very badly preserved and stained, and apparently quite degenerate in structure. In the control drop of pure blood the trypanosomes were all dead or moribund after four hours, and I did not proceed further with it. If any conclusion can be drawn from these experiments, it is that the trypanosomes live, and remain normal, longer when the blood *in vitro* is mixed with water than when it is mixed with salt-citrate solution or left pure; a result which I certainly did not expect.

In preparations the trypanosomes of the perch show a continuous gradation of sizes from the smallest to the largest (figs. 8-14); the larger forms being, however, by far the commonest. The best means of classifying them is by the free flagellum, which in the large stout forms is very short (figs. 13, 14), but in the medium-sized (fig. 12) and small forms (fig. 8) is much longer. The cytoplasm stains a very deep blue with the Giemsa stain, so deeply in fact that it is very difficult to obtain satisfactory preparations of the stout forms; they appear often as bluish opaque masses in which the intensity of the stain obscures all details of structure. In the same preparations, on the other hand, more slender forms may be found perfectly stained. The cytoplasm in the largest forms usually appears blotchy, with lighter and darker parts, often with tiny vacuole-like spaces, not very sharply limited. Any of the forms may contain red-staining granules to a greater or less extent, sometimes very numerous, sometimes absent altogether. The granules in question are of fair size and more or less irregular in form. In one specimen I saw them frequently in pairs, and sometimes rod-shaped, suggesting division (fig. 104); and the idea occurred to me that they might perhaps be intrusive organisms of the nature of Bacteria. In never-dried preparations stained with iron-haematoxylin the cytoplasm appears more or less evenly and coarsely granular, according to the degree of extraction of the stain (figs. 96-99). The above-mentioned granules are not brought out by this stain. I see, therefore, no reason for regarding them as chromidia.

The nucleus appears, in the smears stained by Giemsa's method (figs. 8-14), as a red patch, often obscured and difficult to make out clearly in the large stout forms. It varies in size with the dimensions of the trypanosomes, and is much larger in the large forms. With the Romanowsky stain the details of nuclear structure appear to vary greatly; sometimes a distinct sharply limited karyosome, stained a deeper red than the rest of the nucleus, can be made out (fig. 13), sometimes not. It would appear as if the method of drying had the frequent result of distorting or breaking up the fluid or plastic karyosome, thus producing different appearances in different cases. On the other hand, in never-dried smears stained with Heidenhain's iron-haematoxylin, the structure of the nucleus appears quite uniform in all its principal features (figs. 97-102), in all cases, and can be

described in quite general terms. It is seen that the nucleus is an ovoid or nearly spherical space limited by a delicate membrane. In the interior is a deeply staining karyosome, which may be spherical, ovoid, pear-shaped, or even dumbbell-shaped. The karyosome is always large, and sometimes so large as to nearly fill up the entire nuclear cavity and appears to be immediately surrounded by a clear space. The remainder of the nucleus is occupied by a faintly granular material, which, owing to the excentric position of the karyosome, forms usually a crescentic area on one side of the nucleus. In this area coarser dots of chromatin can be made out, especially in the neighbourhood of the nuclear membrane, which is probably composed also of chromatin. No details of structure could be seen in the karyosome itself.

The foregoing statements apply to the nuclear structure of the large or medium-sized forms, since I was not able, unfortunately, to find any of the small forms, always rare, in my preparations stained with iron-hæmatoxylin.

The kinetonucleus appears as a rounded or ovoid mass in preparations stained by the Romanowsky method. It is larger, both absolutely and relatively, in the very small trypanosomes than in the large. In preparations stained with iron-hæmatoxylin it appears either rod-shaped or rounded in form, but in either case very much smaller in size than it appears when stained by the Romanowsky method. If the hæmatoxylin be not much extracted, the kinetonucleus is often difficult to distinguish from the blepharoplast, the two together appearing to form a single mass of triangular or irregular outline. If, on the other hand, the extraction of the hæmatoxylin be carried too far, the blepharoplast and flagellum become completely decolorized and the kinetonucleus appears as a very sharply defined and deeply stained body, in which no details of structure could be distinguished.

The flagellum arises from a distinct blepharoplast, which can almost always be seen clearly, and usually lies close beside the kinetonucleus. In some cases, however, the blepharoplast and kinetonucleus are separated by a considerable interval, and then appear to be connected by an ill-defined band of material staining more lightly (fig. 98). In the living condition also, as stated above, I observed in some cases two separate grains, which apparently represented the kinetonucleus and blepharoplast.

The flagellum arises direct from the blepharoplast and runs along the edge of the undulating membrane in the usual way. As already stated, the free flagellum is short in the large stout forms, long in those of medium or small size. It is worthy of note that in the smaller forms the free flagellum ends distally in a distinct grain or dot. The undulating membrane is shallow, with many small pleats as a rule, in the stout forms with short free flagellum (fig. 13); but in all forms with a long free flagellum,

and especially in the smallest forms, the undulating membrane is very deep, and stands out far from the body, with fewer and larger pleats (figs. 8-12). It generally appears clear, but in some cases the granules of the cytoplasm can be seen extending up into it, forming a distinct contour-line close under, but quite separate from, the flagellum (fig. 12).

In one of my preparations, which had been fixed first with osmic vapour and then with Schaudinn's fluid, without drying, and stained with iron-hæmatoxylin, I found the trypanosomes showing distinctly striations which are doubtless to be explained as myoneme-filaments (figs. 96, 97). They are to be made out on both surfaces of the body running spirally, and hence appear to cross in the drawing, but in the object they are seen at different foci on the two surfaces. In one trypanosome they appear to run in couples (fig. 96). In another, which was much bent up and probably contracted, the myonemes can be seen on one surface running to a very convex edge, where they appear in optical section as distinct grains, and from this point they can be traced again on the other surface (fig. 97). The exact number was difficult to make out; fig. 96 indicates that there are in all 8, or 4 couples, but in fig. 97 there appear to be more than this. To these myonemes may be referred the active wriggling movements of the trypanosomes.

In some of my preparations stained with Giemsa's stain I found very broad forms of the trypanosome. I am convinced that these forms are simply stout forms of the trypanosome deformed and flattened out by drying. In slides fixed with osmic vapour before drying I find them only at the edge, or in very thin parts of the film, that is to say in places where it is difficult to avoid a slight amount of drying taking place. Two other points are to be noted in favour of this conclusion; one is that the very broad forms are not so opaque as the stout forms which do not show any flattening; the other is that the nucleus is more or less considerably elongated in the transverse direction, having evidently shared in the increase of breadth produced by the flattening.

In one preparation, fixed wet with osmic vapour and stained by Giemsa's method, I found a trypanosome apparently encysted (fig. 15). No trace of a flagellum was to be seen, but the body is rounded off and surrounded by an envelope staining a faint bluish tinge. The shape of the nucleus indicates perhaps that a slight amount of flattening has taken place. No other similar stage was found.

In preparations from a perch which showed abundant trypanosomes in its blood, I found, on two separate slides, two bodies resembling hæmogregarines (fig. 16); they were free in the blood-plasma and strongly resembled the free vermicules of these parasites. It is well known that hæmogregarines occur commonly in marine fishes, but in freshwater fishes they have only been found in the eel. I searched long, but in vain, for intracorpuseular

stages similar to the vermicules; I found, however, in the large uninucleate* leucocytes, bodies which I took at first to be parasites: rounded bodies staining a faint pink (after Giemsa's stain), with a central darker grain or two such grains (figs. 17-19). I could not find, however, anything in the least transitional to the vermicule-like bodies, and I do not think now that the bodies in the leucocytes are of parasitic nature. In the corresponding leucocytes of the tench (figs. 45-48) there are to be found commonly, but not invariably, round pink-staining bodies, sometimes a single one of variable size, sometimes two, three, or four such; they are clearly vacuoles containing some substance which has stained, probably, with the eosin of the Giemsa stain, and I think it very probable that the bodies in the leucocytes of the perch are of a similar nature.

If the vermicules, however, are not stages of a hæmogregarine, in what light are we to regard them? Since they were found in the same blood as the encysted trypanosome already described (fig. 15), the idea occurred to me that perhaps the stout forms of *Trypanosoma perca* might encyst in the internal organs and undergo multiplication to form the vermicule-like bodies; these in their turn might acquire flagella and so give rise to the smallest forms of the trypanosome, which by growth into the large forms would complete a cycle of multiplication in the fish. The rarity of fission-stages of the trypanosomes of fish is remarkable; I have never seen a fish-trypanosome in division, but Laveran and Mesnil have described fission of *T. remaki* in two pike infected artificially, and Lebailly and França have, as stated elsewhere, described fission in *T. granulorum* from cultures *in vitro*. It is therefore quite possible that fission may be a process restricted to certain parts of the life-cycle, and that the usual mode of multiplication in fish-trypanosomes may be such as I have indicated above. In *Trypanosoma lewisi*, for example, fission is only found during the first week or so after inoculation; there is then no further multiplication, the trypanosomes being all of one size and type. On the other hand, fish-trypanosomes usually exhibit marked variations in size which are very suggestive of growth from the smallest to the largest forms. I desire to make this suggestion cautiously, as the data on which it is founded are obviously quite inadequate to establish it. I may point out, however, that the blood in which the encysted trypanosome and the vermicule-like bodies were found, was taken from the heart of the fish with a capillary glass tube, and it is quite possible that the tube in passing through the walls of the heart may have taken up bodies which were not free in the general circulation, but contained in the wall of the heart itself.

* Commonly termed "mononuclear"; a barbarous etymological compound. The adjective "nuclear" means "of or relating to the nucleus"; not "possessing a nucleus."

2. *TRYPANOSOMA GRANULOSUM* Lav. & Mesn. (Plate I. figs. 1-7; Plate V. figs. 78-93.)

The trypanosome of the Eel has been seen by many observers, and there is no other fish-trypanosome which has been the object of so many memoirs. According to Laveran and Mesnil, the first description of this parasite was by Sabrazès and Muratet, but the earlier work of these authors is not accessible to me. The earliest memoir on the subject with which I am acquainted is that of Laveran and Mesnil themselves (1902), in which they figure and describe the parasite and name it *T. granuloseum*. Lebailly (1906) gave a detailed description, with two figures, of this trypanosome and distinguished two varieties, *magna* and *parva*. In the same year Brumpt described the transmission of the trypanosome of the eel by the leech *Hemiclepsis*, and the development that the parasite goes through in this leech. Finally, França (1907) has devoted a memoir to this trypanosome.

Since so much work has been done on the trypanosome of the eel, I did not pay much attention to it, not expecting to be able to add much to our knowledge on this subject. I obtained four eels caught in the Broad and examined one of them, which I found to contain trypanosomes most abundantly, more so than any fish I have yet examined. I made a number of smears and preparations from this eel and then sent all four eels to the kitchen, to be prepared for my next meal; it was not found that infection with trypanosomes impaired appreciably their gastro-nomic properties. I much regretted afterwards that I did not examine the other three eels to see if they were equally well infected.

Sabrazès & Muratet (1904), Lebailly (1906), and França (1907), have all drawn attention to the extraordinary vitality of this trypanosome, and the fact that if a drop of blood containing them be sealed up on a slide under a coverslip, the trypanosomes will live for several days and multiply. I have not imitated these experiments, but I had a drop of blood under a coverslip, not sealed up in any way, in which the trypanosomes were moving actively after 24 hours, less actively after 48 hours, and feebly after 72 hours.

I spent some time watching the movements of this trypanosome, which are extraordinarily snake-like. As in the case of *T. percae*, the movements are of two kinds, conveniently distinguished as wriggling and travelling. They may wriggle for a long time without changing place to any considerable extent, and then they may suddenly start travelling. When they become weaker, after 24 hours under a coverslip, they only wriggle and do not travel, and as they become moribund the wriggling movements become weaker and weaker, till on the third day they are very feeble. When wriggling they twist over and over in S-like curves, appearing at the first glance like a writhing knot. When travelling, I observed them always progressing actively in a definite direction, flagellum forwards, the body twisting from

side to side in even curves like a snake. They frequently stop suddenly, and wriggle actively in one place like an excited earthworm, and then start off again in a new direction. I never saw them travel with the flagellum directed backwards. The undulating membrane is very distinctly seen, and shows beautiful rippling movements. Progression appears to me to be effected chiefly by twists and turns of the body, aided doubtless by the undulating membrane; the flagellum has perhaps chiefly a tactile or guiding function. The kinetonucleus is very distinct in the living condition as a refringent granule a short way from the hinder end. The trophonucleus is more difficult to see during life.

Although my preparations were made only with the object of adding to my collection, they show some points of interest, which I will state briefly.

In the first place my preparations show trypanosomes of all sizes from very small to very large (figs. 1-7). The contrast between the two extremes of the series is surprisingly great, but all possible transitions from one extreme to the other are to be met with. Nor can I find any definite structural features to separate sharply the large and small forms, as can often be done in trypanosomes of other species. The large forms are very granular, while in the smallest granules are absent or scarce, but this feature shows both variations and transitions; the large forms have more pleats in the undulating membrane than the smaller, but the pleats are about the same depth and simply increase in number with the length of the trypanosome. The free flagellum bears about the same proportion, as regards length, to the rest of the body in both large and small forms, though in some large forms it is perhaps relatively shorter. The differences in the nucleus, to which I shall refer presently, are also differences due to a gradually increasing complexity of structure. I cannot therefore find characters to separate sharply the varieties *magna* and *parva* of Lebailly.

A very marked feature of this species, when stained by the Romanowsky method, is the occurrence of numerous granules in the cytoplasm, a peculiarity to which it owes its name. The granules stain purple or blue with Giemsa's stain. In preparations stained with iron-hæmatoxylin, the granules are only to be seen when the stain is not sufficiently extracted (fig. 83); when the stain is most satisfactory and the flagellum and nuclei are sharp and distinct, the characteristic granulations are not to be seen. One of my coverslip-smears is rather uneven and thicker in some parts than in others. In the thicker portions the stain is less extracted than in the thinner parts of the smear, as commonly happens, and hence different degrees of extraction can be found in the preparation. Only a very few trypanosomes show the granules stained and standing out sharply; with too slight extraction of the stain the granulations are obscured by the darkness of the cytoplasm. If the stain is very much over-

extracted, as in one of my preparations, the colour comes out of everything except the kintoneucleus; when the extraction has not gone quite so far, the karyosome of the trophonucleus also retains the black colour. The granulations of the cytoplasm are not, in my opinion, to be regarded as chromidia, since they give up the stain very readily, while the true chromatic structures retain it very tenaciously.

França has drawn attention to the peculiar structure of the nucleus in the variety *magna* of this trypanosome. He writes:—"Le noyau s'éloigne par sa structure de celui de presque tous les Trypanosomes. Au sein d'une substance incolore on voit la chromatine formant d'ordinaire deux parties bien distinctes; un grand bloc d'un rouge vif, situé dans la partie du noyau la plus rapprochée du blepharoplaste; et un grand nombre de granulations petites et régulières, ou un reticulum chromatique, vers le côté du flagelle. Dans quelques parasites, plus rares, on ne voit pas le grand bloc de chromatine et alors il existe dans la substance nucléaire incolore une série de granulations disposées de façon à former un cordon plus au moins sinueux." "Au contraire de ce qui existe dans le noyau des Trypanosomes de la var. *magna*, dans ceux de la var. *parva* il n'y a pas une distinction nette entre les portions chromatique et achromatique."

França's observations appear to have been made on trypanosomes stained by the Romanowsky method, and my preparations coloured with Giemsa's stain confirm his statements. But I do not believe it is possible to get a coherent or intelligible idea of the structure of the nucleus with this method of staining. My preparations stained with iron-haematoxylin show appearances quite different from those seen after use of the Romanowsky stain, and at the same time permit of a uniform interpretation of the structural details. The nucleus appears very much smaller and more compact after iron-haematoxylin than after the Romanowsky stain; and while it is possible that there is a certain amount of shrinkage by the former method, I think there is certainly a considerable amount of artificial expansion and deformation consequent on the process of drying by the ordinary method of applying the Romanowsky stain.

In never-dried preparations stained with iron-haematoxylin, the smallest trypanosomes (figs. 78, 79) show the nucleus as a clear oval space with a distinct limiting membrane, containing a sharply defined karyosome of elongate-oval form. The karyosome is far from filling up the entire nuclear space, which appears clear or shows very minute granulations. A nucleus of this type of structure may be found even in trypanosomes of large size (fig. 87), but the karyosome in such specimens is considerably larger and fills up nearly the whole nuclear cavity. As a rule, however, in trypanosomes only slightly larger than the smallest that can be found (figs. 80, 81), the karyosome is seen to have budded off from one extremity, usually from that furthest from the kintoneucleus, a smaller part. This is the type of nucleus

most commonly found, one in which there are two karyosomes, either subequal, or markedly unequal, in size (figs. 85, 86, 93). But in many of the large forms the karyosome may be further broken up into three or even four parts, usually differing greatly in size (figs. 89-92). Thus, with endless variations in detail, a similar type of nuclear structure occurs with monotonous regularity in all the preparations stained with iron-haematoxylin; always an oval space containing one or more deeply stained karyosomes. What may be the significance of the disruption of the karyosome I am unable to say.

The kinetonucleus appears after iron-haematoxylin as a rounded or rod-shaped body of minute size. After staining by the Romanowsky method it appears very much larger and of various shapes which are seen in my figures. Near it a distinct blepharoplast can be made out, from which the flagellum arises directly. The free flagellum is usually of considerable length. The undulating membrane does not stand out so boldly from the body as in some species of fish-trypanosomes. In one preparation I saw distinctly a line under the flagellum (fig. 82), indicating doubtless the limit of the extension of the endoplasm into the undulating membrane. Only in one specimen was I able to make out myonemes (fig. 84). They appeared as delicate lines, about three being visible on the side of the body, a number which may correspond to the total of eight alleged to be typical of trypanosomes.

3. TRYPANOSOMA REMAKI Lav. & Mesn. (Plate II. figs. 20-26.)

The trypanosome of the Pike has been described by Laveran and Mesnil (Arch. Protist. i. 1902, pp. 482-486, figs. 1-9). I have very little to add to their description of this parasite, which I found in four out of the five pike examined by me at Sutton Broad. Laveran and Mesnil have noted that this parasite has a wide distribution in Europe, its occurrence having been noted by several naturalists.

Laveran and Mesnil noted two forms which they distinguished as var. *parva* and var. *magna*. I found these varieties very distinctly marked in the pike examined, and without any transitional forms connecting the two extreme types. Both var. *parva* and var. *magna* are subject to slight variations in size, but I found no difficulty whatever in distinguishing the two types in my preparations, whether fixed by osmic vapour or by the ordinary method of drying. The var. *parva* (figs. 20-22, 25) is clearer, with but few coarse granulations, its undulating membrane is shallow and does not stand out sharply from the body, and its free flagellum is longer, relatively and absolutely, than that of var. *magna* (figs. 23, 24, 26), which contrasts with it not only in greater dimensions, but also in its opaque cytoplasm full of coarse granules staining reddish with the Giemsa stain, and in its very prominent undulating membrane. The kinetonucleus also seems to be slightly larger in var. *parva* than in var. *magna*; but I am not able, unfortunately, to make precise statements concerning

the nuclear structure, since in the smears which I stained with iron-hæmatoxylin I was unable to find any trypanosomes, though *Trypanoplasma gurneyorum* was abundant.

4. *TRYPANOSOMA TINCE* LAV. & MESN. (Plate II. figs. 27-29 ; Plate IV. figs. 74-76).

The trypanosome of the Tench was described and named by Laveran and Mesnil (*Trypanosomes et Trypanosomiasés*, Paris, 1904, pp. 387, 388, fig. liii. 2 & 3). Its occurrence had been noted previously by Doflein (*Die Protozoen als Parasiten etc.*, Jena, 1904, p. 71), and since then by Keysselit (Arch. Protist. vii. 1906, p. 3). Doflein considered that the parasite seen by him might be identical with *Trypanosoma carassii* from *Carassius vulgaris*, but Laveran and Mesnil regarded it as a distinct and new species, and described it as follows:—

“La longueur est de 35μ en moyenne, la largeur de $2\frac{1}{2}\mu$ à 3μ . L'extrémité postérieure est conique, peu effilée. Le centrosome, assez gros, est voisin de l'extrémité postérieure. Le noyau est situé vers la partie moyenne du corps du parasite. La membrane ondulante est large, bien plissée. La partie libre du flagelle est assez longue.”

I found trypanosomes in all tench examined by me at Sutton Broad, occurring together with *Trypanoplasma keysseliti*, and have observed nothing to prevent me identifying them with *Trypanosoma tince* of Laveran and Mesnil. This trypanosome appears to be very uniform in size and structure, so far as my observations extend; the two specimens figured by Laveran and Mesnil differ somewhat in size. In my never-dried preparations fixed with Schaudinn's fluid, with or without previous fixation with osmic vapour, and stained with iron-hæmatoxylin (figs. 74-76), the trypanosomes appear constantly smaller than they do in preparations fixed wet with osmic vapour, or dried before fixation, and stained with Giemsa's stain; but I attribute this difference to the effects of the method of fixation.

In osmic-fixed preparations the trypanosome shows, as Laveran and Mesnil have stated, a very broad undulating membrane, standing out well from the body, and continued into a free flagellum of moderate length (figs. 28, 29, 36); the cytoplasm is opaque in such preparations and usually shows numerous coarse granules, which stain reddish with Giemsa's stain, and by the iron-hæmatoxylin method appear black and hold the stain fast. The kinetonucleus appears large after Giemsa; but very much smaller after iron-hæmatoxylin, and by the latter method shows two types of form, rounded and rod-shaped (figs. 74-76). The blepharoplast is not easily seen in the Giemsa preparations, owing to the opacity of the cytoplasm, but in iron-hæmatoxylin preparations it appears as a sharp dot near the kinetonucleus. The trophonucleus appears after Giemsa stain as an oval patch showing no details of structure; after iron-hæmatoxylin it appears as a rounded or oval space, not very sharply limited, containing

a very large round karyosome. In one preparation the karyosome appeared to fill the whole nuclear space and to be of irregular form (fig. 75); a result perhaps due to insufficient extraction of the stain.

5. *Trypanosoma abramis* Lav. & Mesn. (Plate II. figs. 30-32.)

The occurrence of trypanosomes in a Bream was noted by Laveran and Mesnil in 1902 (Arch. Protist. i. p. 478) and the species was named by these authors, but without any figure or description, in 1904 (Trypanosomes et Trypanosomiasis, p. 388). Keysselitz also noted the occurrence of this parasite (Arch. Protist. vii. p. 3). According to Brumpt, the trypanosome of the bream goes through its development in the leech *Hemiclepsis*.

In my preparations of the blood of the bream from Sutton Broad I have found a trypanosome very sparingly; three specimens altogether, one from one fish, two from the other. The trypanosome is of large size and presents no character by which I can distinguish it morphologically from *Trypanosoma tinca*. I consider it very probably identical with this species; in which case the name *tinca* has priority over *abramis* by one page; but in view of the scantiness of my observations I refrain from taking the step of merging the two species into one.

6. *Trypanoplasma gurneyorum*, sp. n. (Plate II. figs. 33-39; Plate IV. figs. 56-65.)

The occurrence of a trypanoplasma in the Pike has only been noted, so far as I am aware, by myself (Quart. Journ. Micr. Sci. lii. p. 253, text-fig. B). I found it abundantly in all pike examined at Sutton Broad, usually occurring together with *Trypanosoma remaki* Lav. & Mesn.; in one pike, however, I found a very abundant infection with the trypanoplasma, but no trypanosomes. I propose to name this trypanoplasma *T. gurneyorum*, in honour of Messrs. Eustace and Robert Gurney, in whose laboratory this work was done.

Trypanoplasma gurneyorum occurs under two forms, which I will distinguish as "ordinary" and "large." The large forms appear to be very scarce; I have seen only two specimens so far, both in preparations from the fish mentioned above, in which only trypanoplasms were found. The ordinary form of *T. gurneyorum* (figs. 33-37) is characterized by a fairly broad undulating membrane and by the shortness of the free flagella. The anterior free flagellum is scarcely more than half the length of the body. The posterior free flagellum projects only a very short distance beyond the hinder end of the body; in some specimens it is rather longer, but it is always short by comparison with other trypanoplasms. The trophonucleus is near the middle of the body, sometimes even in the posterior half. The form of the anterior extremity of the body shows variations, which are perhaps due

partly to the animal's movements, partly to deformations induced by fixation. Sometimes the anterior end appears pointed and the marginal flagellum runs backwards from its point of origin (fig. 36). On the other hand, the anterior end may be very blunt and rounded, and the marginal flagellum runs first forwards and then backwards from its point of origin (fig. 33). The second type is found in an extreme form in preparations dried before fixation (fig. 37), and is then undoubtedly largely a case of deformation; the chief mass of the body seems to flow forwards when dried, with the result of bringing the kinetonucleus and trophonucleus close together. In extreme cases the trypanoplasma becomes a shapeless mass, in which the orientation of the body is difficult to make out (figs. 38, 39). It is interesting to note that trypanoplasma deformed in this way beyond recognition occur in preparations in which the trypanosomes have their body form and structural characters preserved quite perfectly.

The large form of *Trypanoplasma gurneyorum* (fig. 56) also has the free flagella relatively short. The body cytoplasm is very dense and opaque, staining a very deep blue with Giemsa's stain, so that it is very difficult to make out the nucleus; in the specimen drawn in outline in fig. 56 I could see the kinetonucleus plainly, especially with green light, but the trophonucleus was very difficult to distinguish from the cytoplasm, and I am by no means certain that I have drawn it correctly.

The most remarkable feature of *Trypanoplasma gurneyorum* is the presence of deeply staining granules in the cytoplasm. They occur chiefly towards the hinder end of the body, but are found also, though more sparingly, up to the anterior extremity. By the Romanowsky method (figs. 33-39) they stain deeply in a colour approaching the tint of the nuclei, and more especially that of the kinetonucleus. By the iron-haematoxylin method they hold the stain very fast (figs. 57-65), quite as fast as do the nuclei, a point in which they contrast with the cytoplasmic granules of *Trypanosoma granulorum* and *T. percae*. The granules are especially sharp and clear in preparations fixed with sublimate-acetic and stained with iron-haematoxylin (figs. 57-61). They are rounded and vary in size from small dots to coarse grains. Sometimes there are only a few granules, but as a rule they are very numerous and give this trypanoplasma a very characteristic appearance.

The nuclei of *Trypanoplasma gurneyorum* appear very different according to the stain used, Romanowsky or iron-haematoxylin. The trophonucleus is lodged in or near the edge of the undulating membrane, and hence is difficult to make out clearly if the undulating membrane in this part be folded over the body. It appears after the Romanowsky stain as a lightly stained patch, more or less oval in form, showing no detail or only a few irregular granulations. After iron-haematoxylin (fig. 57-64) it appears as a clear oval space, not very well defined, containing

usually a single karyosome. In the ordinary forms the karyosome is small, often no larger than one of the coarser cytoplasmic granules, with which it may be confused very easily, so that at first sight the trypanoplasms appear to have no trophonucleus. In the only specimen of the large forms which I have seen stained by this method, the karyosome was very large and almost filled the nuclear space (fig. 65). In one specimen of the ordinary forms I found what appeared to be nuclear division (fig. 62); two karyosomes connected by a distinct curved black line, one of them in the ordinary position of the trophonucleus, the other further forwards, on a level with the kinetonucleus. In another specimen the karyosome appeared to be budding off a smaller part (fig. 59), perhaps as a preliminary to division.

The difference between the nucleus in specimens stained by the Romanowsky and the iron-hæmatoxylin methods is very striking. One sample, however, of Giemsa's stain which I used gave different results from all others, for some unexplained reason; with this sample the flagellum stained blue instead of red, and the trophonucleus appeared as a small granule (fig. 36), just as in the iron-hæmatoxylin preparations; the kinetonucleus appeared very large. Hence all the trypanoplasms stained with this sample of stain gave the impression, at first sight, of lacking a trophonucleus.

The kinetonucleus appears very large after the Romanowsky stain, much smaller after iron-hæmatoxylin, but in both cases larger, as a rule, than the trophonucleus. There are two types of form exhibited by the kinetonucleus: a more rounded or oval, broader type (figs. 57, 59), and a more elongated, band-like type (figs. 61, 64); the latter often appears to have a small piece at the anterior end constricted off from the main body (figs. 58, 64; compare Keysselitz, Arch. Protist. vii. p. 36, fig. 45). The kinetonucleus stains an even black in iron-hæmatoxylin, a deep purple after Giemsa, and shows no structural detail. Having only seen two specimens of the large form of this trypanoplasm, I am unable to say if distinct types of kinetonucleus are exhibited by it, as by the large forms of *T. keysselitzi*. In front of the kinetonucleus are two minute blepharoplasts from which the flagella arise. After the Romanowsky stain the blepharoplasts appear a fair size and are distinctly seen; after iron-hæmatoxylin, on the contrary, they are very minute and often appear as a single granule, being close together and difficult to resolve into two distinct dots. When the anterior end of the body is drawn out, the blepharoplasts appear sometimes one behind the other, and with a considerable interval between them.

The following is an attempt at a brief diagnosis of *Trypanoplasma gurneyorum*:—Occurs under two forms, ordinary and large; trophonucleus near middle of body, with single karyosome; kinetonucleus compact or drawn out, large; anterior flagellum of moderate length; free portion of posterior flagellum very short. Host, *Esox lucius*, Norfolk.

7. *TRYPANOPLASMA KEYSSELITZI*, sp. n. (Plate III. figs. 40-44; Plate IV. figs. 66-73.)

The occurrence of a trypanoplasm in the Tench has been noted by Keysselitz (Arch. Protist. vii. p. 3), but the species has not been described in detail, so far as I am aware, or named. Since it appears to me to be a well-marked species characterised by several striking peculiarities of structure, I propose to name the trypanoplasm of the Tench *Trypanoplasma keysselitzi*, in honour of Dr. Keysselitz, who was the first, I believe, to observe it. From the figure given, however, by Lühe (Mense's Handbuch, iii. fig. 5, p. 83) of the trypanoplasm of the Carp, I think it possible that *T. keysselitzi* may prove to be a synonym of *T. cyprini* Plehn.

Trypanoplasma keysselitzi was found in all the tench examined by me at Sutton Broad, always in company with *Trypanosoma tincae*. In some of the tench examined it was very abundant. In one case I saw as many as four or five in a field (Zeiss Oc. 4 Obj. D) in a drop of fresh blood under the coverslip. In other cases the parasites were scarcer, but in no case was I unable to find them.

The trypanoplasms occur under two distinct forms: one smaller, which, as it is the most abundant, I will call the ordinary form (figs. 42, 43); the other, less common, I will refer to simply as the large form (figs. 40, 41). The two forms are easily distinguished in the living state in the fresh blood. In preparations they are seen to be distinguished not only by differences in size but also by points of structure. The posterior flagellum is continued beyond the undulating membrane as a relatively very long free flagellum in the ordinary forms, but the free portion is quite short in the large forms. There are also differences in the nuclear structure, presently to be described, between the ordinary and the large forms, and by this feature the large forms can also be separated into two types.

The cytoplasm is finely and densely granular, and in the large form opaque and deeply-staining, but it is relatively free from the coarse granules which are such a feature of *T. gurneyorum*. In iron-hæmatoxylin preparations only a few coarse granules are to be seen, sometimes none at all.

The two nuclei of this trypanoplasm are remarkable, in the first place, for being situated very close together. The trophonucleus, always placed at the edge of the undulating membrane, is never more than a short way behind the kinetonucleus, which it usually overlaps at the hinder end, and sometimes even the trophonucleus is opposite the middle of the kinetonucleus. The arrangement of the two nuclei gives this trypanoplasm a very characteristic figure and appearance.

The trophonucleus shows well-marked variations of structure. In the ordinary forms, when stained with iron-hæmatoxylin, it is a small oval clear space which contains two distinct karyosomes (figs. 70-72). These bodies may appear as small dots, looking like two granules of the cytoplasm, or they may be larger, but

the number is constant, so far as my observations extend. One karyosome is often slightly larger than the other. When the trypanoplasma lies in a certain position, the karyosomes may be quite hidden under the opaque kintonucleus, and then the trophonucleus cannot be made out at all. In the large forms, on the other hand, the trophonucleus shows either one large karyosome which almost fills the nuclear cavity (fig. 69), or one large and one or two smaller karyosomes (figs. 67, 68). There are further differences to be observed in the trophonuclei of the large forms which appear to be correlated with differences in the kintonuclei. Usually a large trophonucleus with a very large karyosome is correlated with a relatively short kintonucleus (fig. 69). On the other hand, a small trophonucleus may be found combined with a very long kintonucleus (fig. 67). According to Keysseltz the large forms of the trypanoplasma are gametes, those with the large kintonucleus being male forms, and those with smaller being female. I am not in a position to criticise or comment upon this statement.

The kintonucleus is situated on the side of the body furthest from the undulating membrane, and is remarkable for its great length, being narrow and band-like, never rounded, oval or pear-shaped. As already stated, its length varies in different specimens. With iron-hæmatoxylin it always stains an even black and shows no structure: in one specimen which had been very much extracted (fig. 72) it appeared very narrow and linear in form, with a clear space in the cytoplasm on one side.

In front of the kintonucleus are situated the two minute blepharoplasts from which the flagella arise. I believe them to be always two in number, but in iron-hæmatoxylin preparations they are so minute and often so close together that it is impossible to resolve them as two granules and they may appear as a single dot. There appears to be a streak or fibre connecting the kintonucleus with the blepharoplasts, but the length of the connection, that is the distance between the two structures, is variable.

The following is an attempt at a brief diagnosis of *Trypanoplasma keysseltzi*:—Occurs under two forms, distinguished by size and by structural characters; in both forms the two nuclei very close together at the anterior end of the body; kintonucleus very elongated, trophonucleus small; posterior free flagellum long in the smaller forms, short in the larger forms. Host, *Tinca vulgaris*, Norfolk.

8. *TRYPANOPLASMA ABRAMIDIS* Brumpt. (Plate III. figs. 49–54; Plate IV. fig. 77.)

The trypanoplasma of the Bream has been described by Brumpt (CR. Soc. Biol. lx. 1906, p. 164) in the following words:—

“Dans le sang de la Brème. Vu seulement à l'état frais. Le corps possède alors 30 μ de long sans compter les flagelles, l'anérieur ayant environ 15 μ de long, le postérieur 5 et 6 μ seulement. Ce

parasite évolue exclusivement chez l'*Hemiclepsis* et ne passe jamais dans la gaine de la trompe, ce qui permet de le distinguer des espèces déjà connues de la Carpe et des Loches."

The occurrence of trypanoplasms in the bream has also been noted by Keysselitz (Arch. Protist. vii. 1906, p. 3).

I found trypanoplasms fairly abundantly in all the bream examined by me at Sutton Broad. It is unnecessary to give a detailed description; my figures show their general appearance. The body is rather slender and not very granular. The anterior flagellum is fairly long, the posterior free flagellum moderately so. The trophonucleus is about on a level with the hinder end of the kinetonucleus. I did not stain any preparations with iron-hæmatoxylin, so can say nothing about the minute structure of the nuclei. I did not find any trypanoplasms of large size, as in other species.

In its characters *Trypanoplasma abramidis* appears to be more or less intermediate between *T. keysselitzi* and *T. gurneyorum*, but distinct from either.

TRYPANOPLASMA BORRELI Lav. & Mesn. (Plate III. fig. 55.)

The trypanoplasma of the Rudd (*Leuciscus erythrophthalmus*) is the type-species of the genus *Trypanoplasma*; it was described under the name *T. borreli* by Laveran & Mesnil in 1902 (Arch. Protist. i. p. 489). The Rudd and Roach are very abundant in Sutton Broad, perhaps the two commonest species of fish there, and I examined a great number of specimens of each species for blood-parasites; only in one rudd, however, was I successful in finding them. I saw one trypanoplasma in the fresh blood, and made several smears from the same fish. After very prolonged searching of the smears a single trypanoplasma was found, which both from its occurrence in the Rudd and from its resemblance to the figures of Laveran & Mesnil and Léger, I have no hesitation in identifying as *T. borreli*. From the single specimen before me, *T. borreli* appears to resemble *T. keysselitzi* in the length of its free flagella, but differs in having the trophonucleus further back (fig. 55).

EXPLANATION OF PLATES I.-V.¹

All figures are drawn with the camera lucida to a magnification of 2000 linear; with the exception of fig. 77, Plate IV., and figs. 94, 95, Plate V., which are drawn from the living object freehand.

PLATE I.

Figs. 1-7. *Trypanosoma granulosum* of the Eel, a series to show the gradations in size between the smallest and the largest forms. All from the same blood, and all, except fig. 7, from the same slide. Preparations dried off, then fixed with absolute alcohol and stained with Giemsa's stain.

Figs. 8-14. *Trypanosoma percae* of the Perch, various forms. 8-11, small forms; 12, medium-sized form with long free flagellum; 13, 14, stout forms with short free flagellum; 8 & 12-14 from preparations dried off and fixed with absolute alcohol; figs. 9-11, from preparations fixed with osmic vapour followed by absolute alcohol; all stained with Giemsa's stain.

- Fig. 15. Encysted form of *Trypanosoma percae*, from the same slide as 9 and 10. Osmic vapour, absolute alcohol, Giemsa.
- Fig. 16. Young form of *T. percae*? or vermicle of a hæmogregarine? From the same slide as the last.
- Figs. 17-19. Leucocytes of the Perch, showing peculiar enclosures. From a preparation dried off, fixed with absolute alcohol, and stained with Giemsa's stain.

PLATE II.

- Figs. 20-26. *Trypanosoma remaki* of the Pike. 20-22 & 25, small forms (var. *parva*); 23, 24, & 26, large forms (var. *magna*); 20-24, from preparations fixed with osmic vapour followed by absolute alcohol; 25, 26, from preparations dried off, fixed with absolute alcohol, all stained with Giemsa's stain.
- Figs. 27-29. *Trypanosoma tincae*, from the Tench. 27, dried, absolute alcohol, Giemsa; 28, 29, osmic vapour, absolute alcohol, Giemsa.
- Figs. 30-32. *Trypanosoma abramis*, from the Bream. 30, 31, osmic vapour, absolute alcohol, Giemsa; 32, dried off, absolute alcohol, Giemsa.
- Figs. 33-39. *Trypanoplasma gurneyorum*, from the Pike. 33-36, osmic vapour, absolute alcohol, Giemsa; 37-39, dried off, absolute alcohol, Giemsa.

PLATE III.

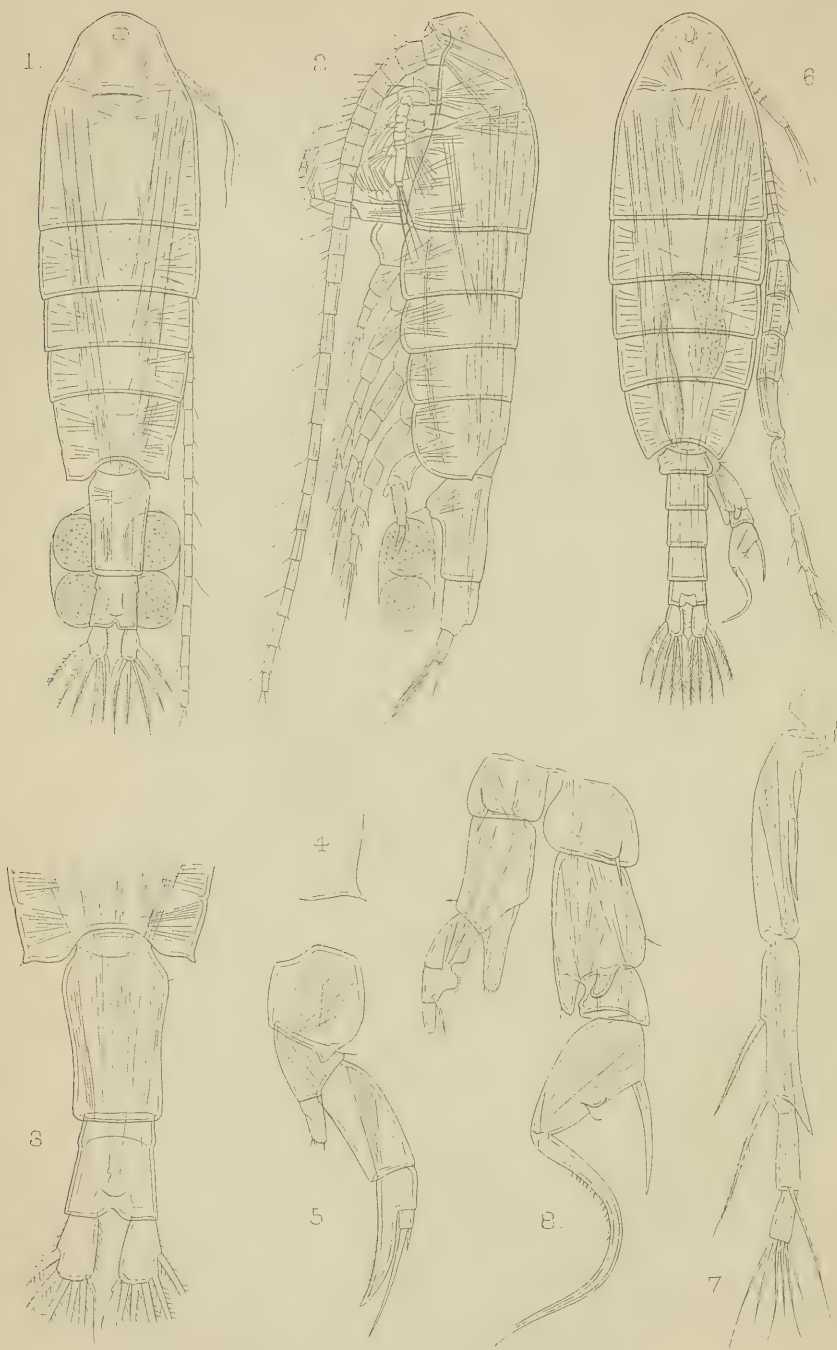
- Figs. 40-44. *Trypanoplasma keysselitzi*, from the Tench. 40, 41, large forms; 42-44, ordinary forms; 40-43, osmic vapour, absolute alcohol, Giemsa; 44, dried off, absolute alcohol, Giemsa.
- Figs. 45-48. Large uninucleate leucocytes of the Tench, showing peculiar pink-staining enclosures; preparation dried off, fixed with absolute alcohol, stained with Giemsa's stain.
- Figs. 49-54. *Trypanoplasma abramidis*, from the Bream. 49, fixed with sublimate-acetic (95:5); 50-52, fixed with osmic vapour followed by absolute alcohol; 53, 54, dried off, fixed with absolute alcohol; all stained with Giemsa's stain.
- Fig. 55. *Trypanoplasma borreli*, from the Rudd. Osmic vapour, absolute alcohol, Giemsa.

PLATE IV.

- Figs. 56-65. *Trypanoplasma gurneyorum*, from the Pike. 56, large form, from a preparation stained with Giemsa's stain, all the others from preparations stained with iron-hæmatoxylin; 56, osmic vapour, absolute alcohol; 57-61 & 63, sublimate-acetic (95:5); 62, 64, 65, Mann's picro-corrosive with formol.
- Figs. 66-73. *Trypanoplasma keysselitzi*, from the Tench; all from preparations stained with iron-hæmatoxylin. 66-69, large forms; 70-73, ordinary forms; 66, Schaudinn's fluid; 67 & 70, sublimate-acetic (95:5); 68, 69, & 71-73, Mann's picro-corrosive with formol.
- Figs. 74-76. *Trypanosoma tincae*, from the Tench, all from preparations stained with iron-hæmatoxylin; 74, Schaudinn's fluid direct; 75-76, Schaudinn's fluid preceded by exposure to osmic vapour.
- Fig. 77. *Trypanoplasma abramidis*, from the Bream, sketched living.

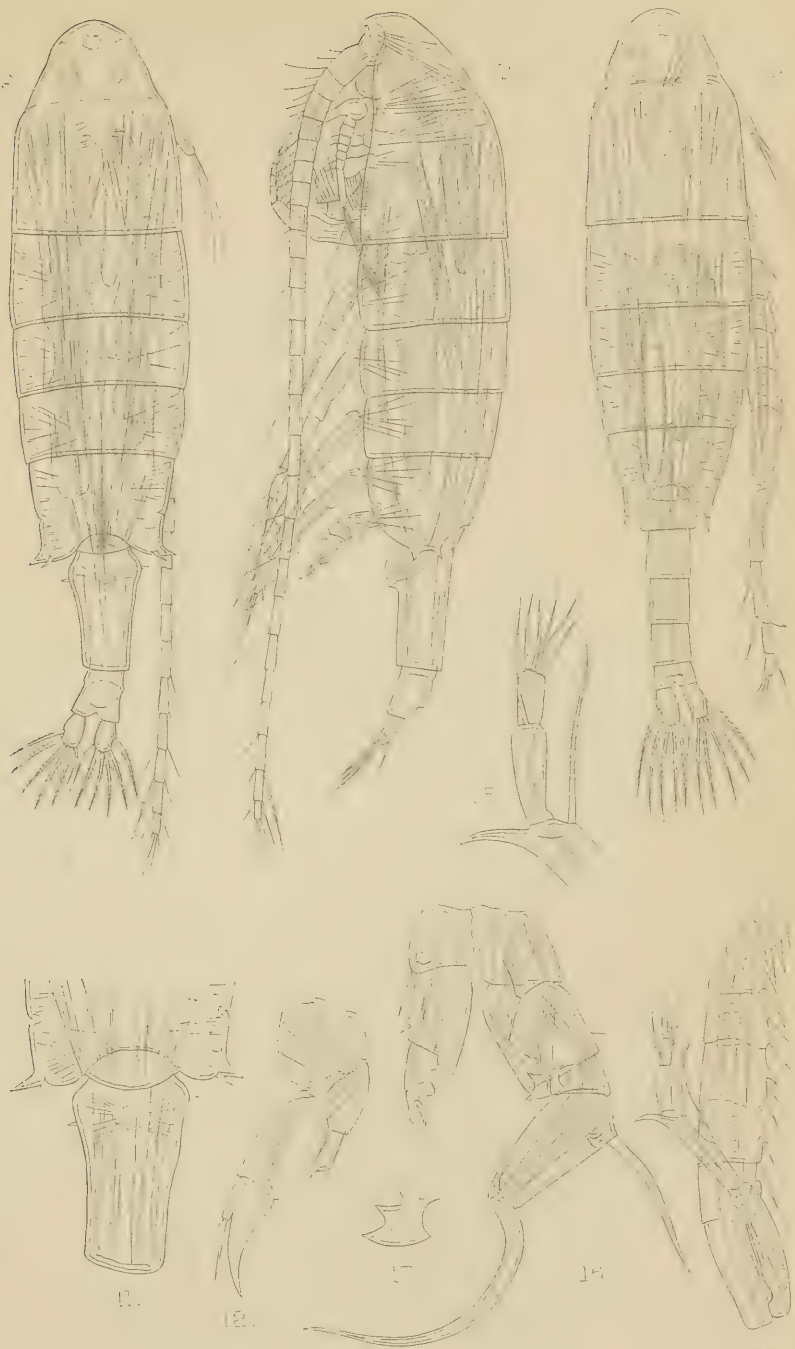
PLATE V.

- Figs. 78-93. *Trypanosoma granulorum*, from the Eel, all from preparations stained with iron-hæmatoxylin. 78-82 & 85-93, fixed with Mann's picro-corrosive-formol mixture; 83, 84, fixed with sublimate-acetic (95:5). 78-80. Small forms.
- 81-82. Medium-sized forms; in 82 only the posterior part figured, to show the double line in the undulating membrane, the outer line representing the flagellum, the inner line representing the limit of the extension of the endoplasm into the membrane.
83. Large form, anterior half, the stain but slightly extracted, showing the cytoplasmic granules; whole length of the flagellum not drawn.
84. Large forms, anterior half, stain under-extracted, showing the myonemes; whole length of the flagellum not drawn.
85. Large form.
- 86-93. Trophonuclei of different specimens, all from the same preparation, and all from large forms.

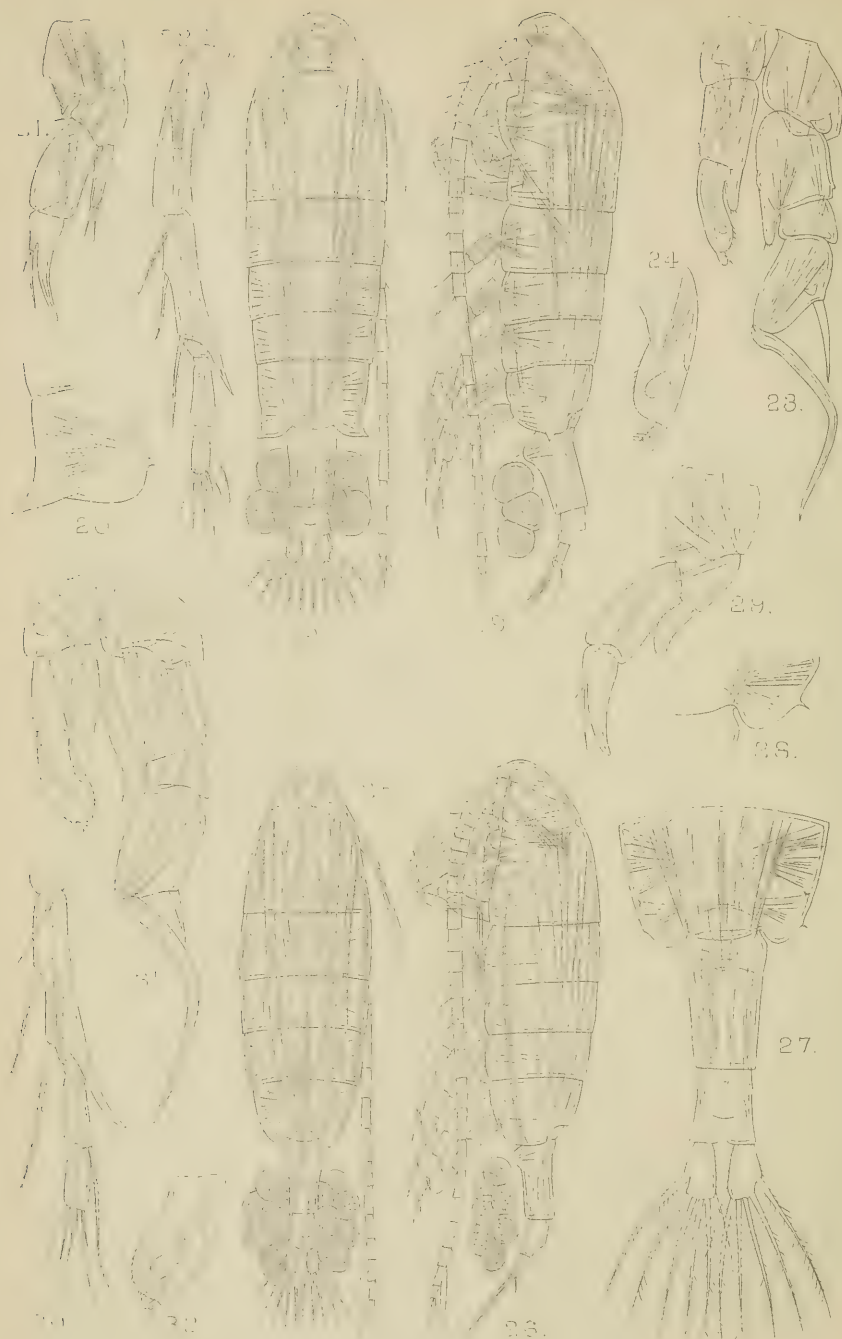


M. F. Paulsen.

DIAPTOMUS GALEOIDES, G. O. Sars.

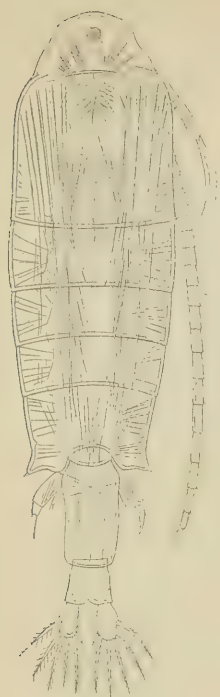


DIAPTOMUS MIXTUS, G. O. Sars.



M. P. Parker del.

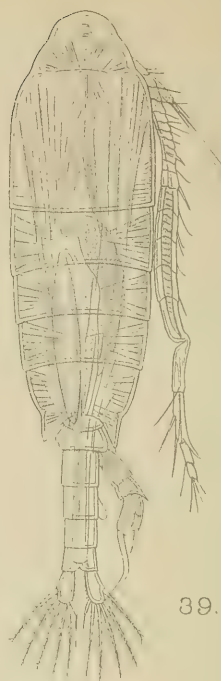
13-24. *DIAPRIIDAE* *STUELMANNI*, Mrázek.
25-32. *BRACONIDAE* *STUELMANNI*, Mrázek.



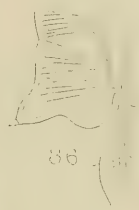
33.



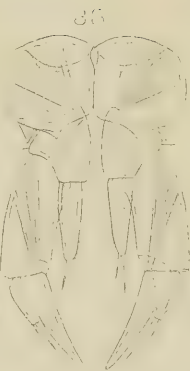
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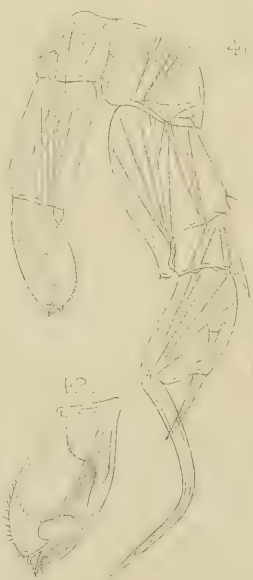
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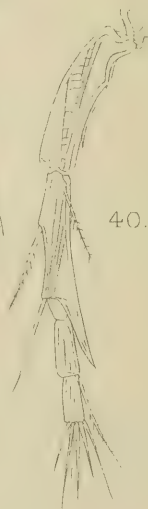
36.



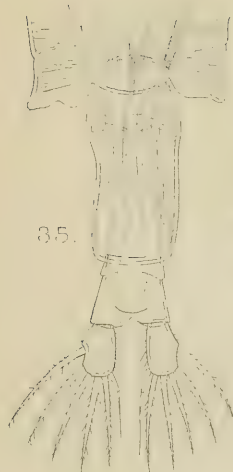
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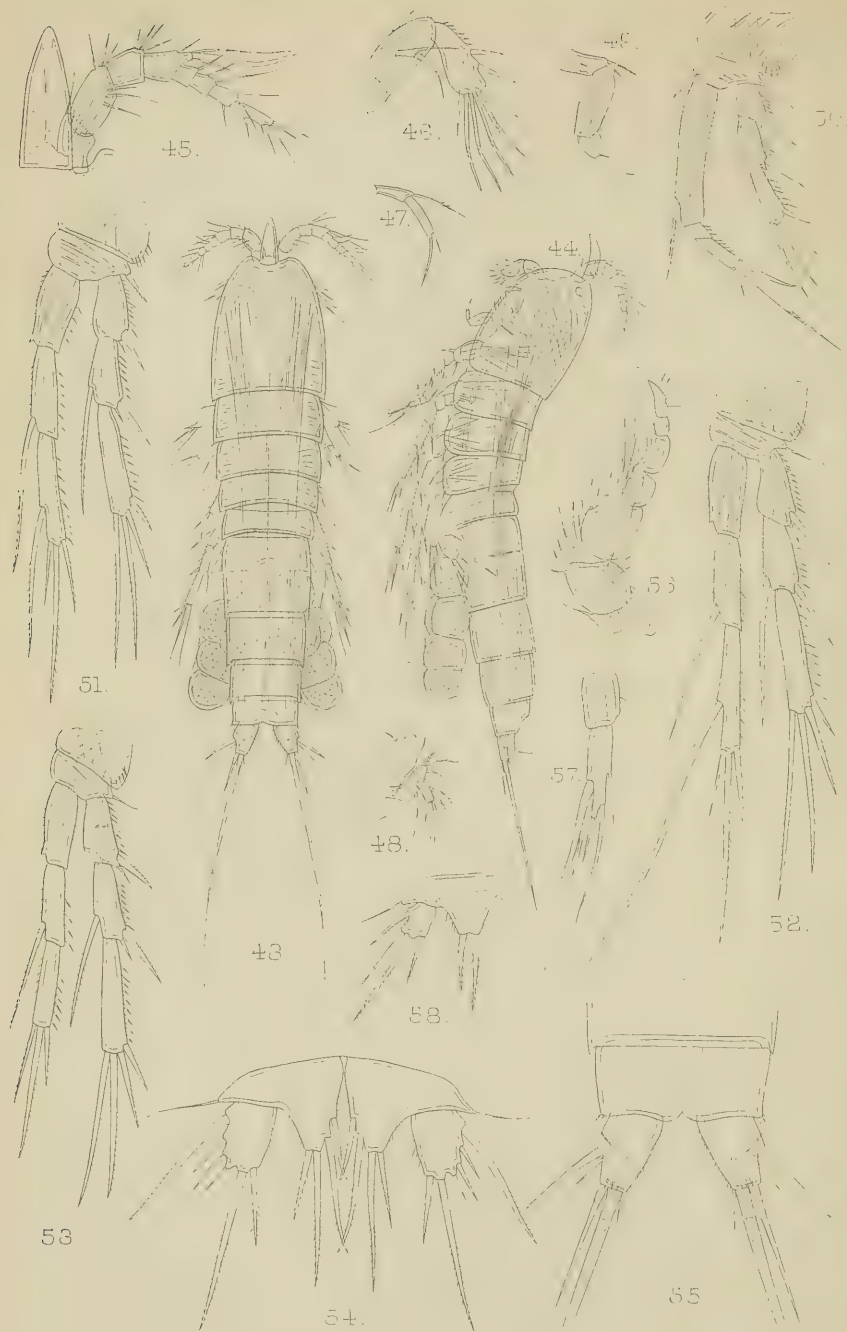
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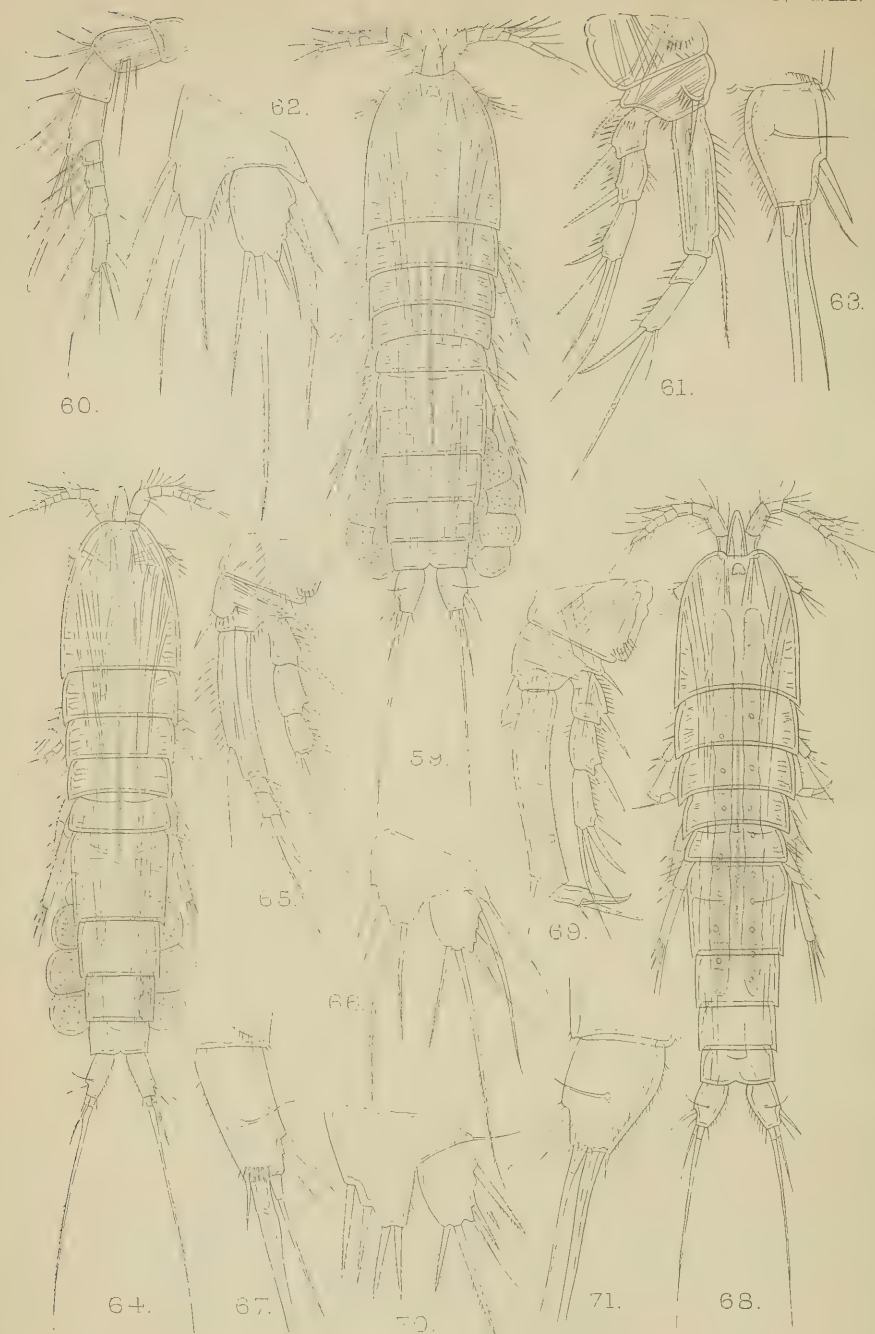


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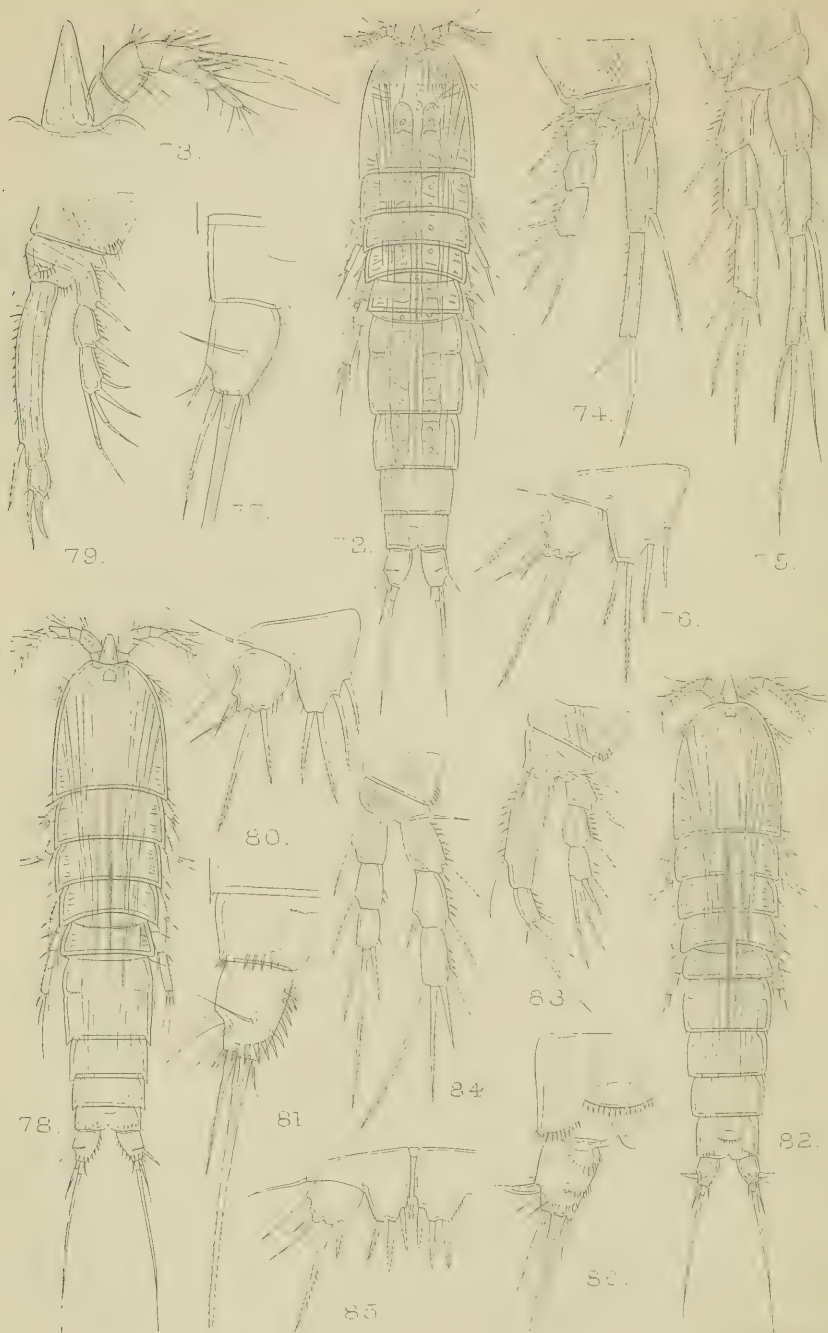
35.





M. P. Parker, lith.

59-63, *SCHIZOPERA VALIDIOR*, G. O. Sars.
 64-67, *SCHIZOPERA CONSIMILIS*, G. O. Sars.
 68-71, *SCHIZOPERA UNGULATA*, G. O. Sars.



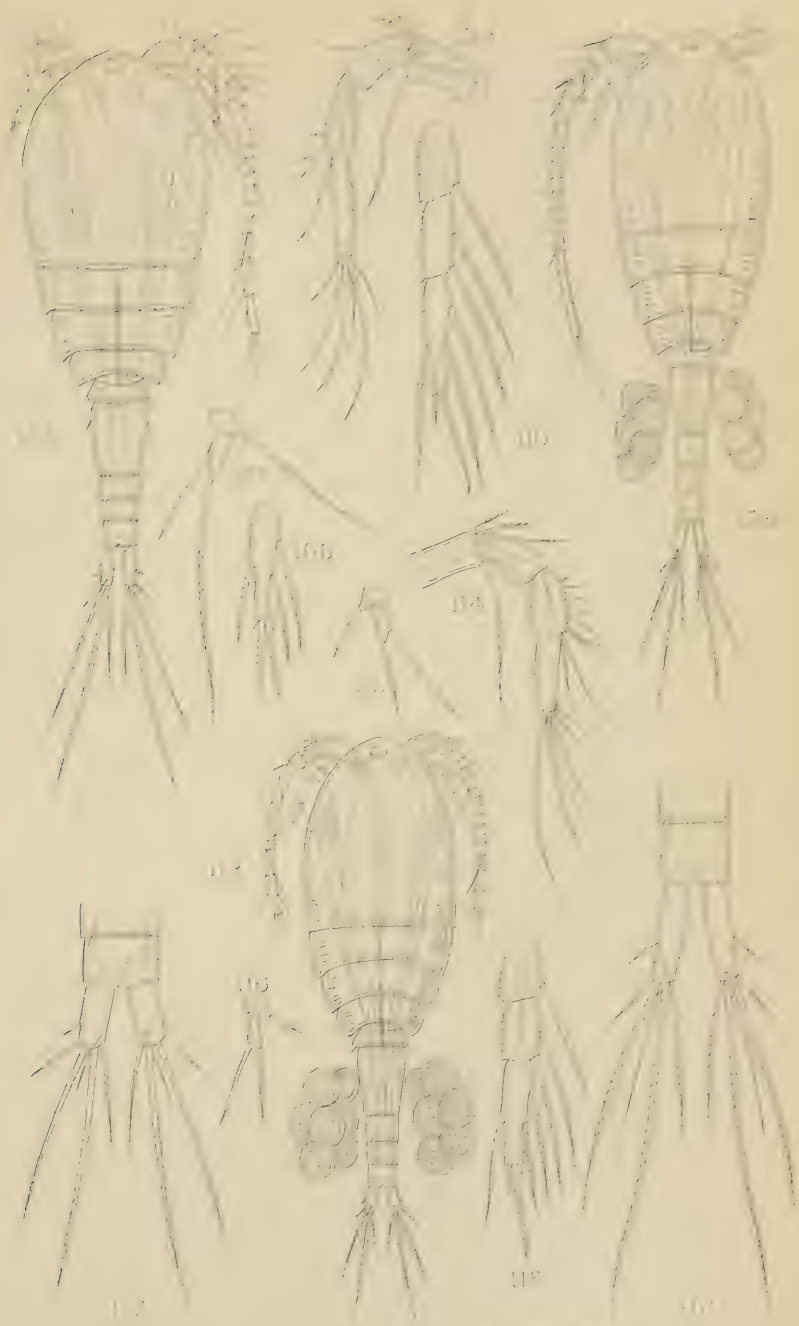
MP Parker Ill.

72-77, *SCHIZOPERA MINUTICORNIS*, G.O. Sars.78-81, *SCHIZOPERA SPINULOSA*, G.O. Sars.82-86, *SCHIZOPERA PINNATIFIDA*, G.O. Sars.



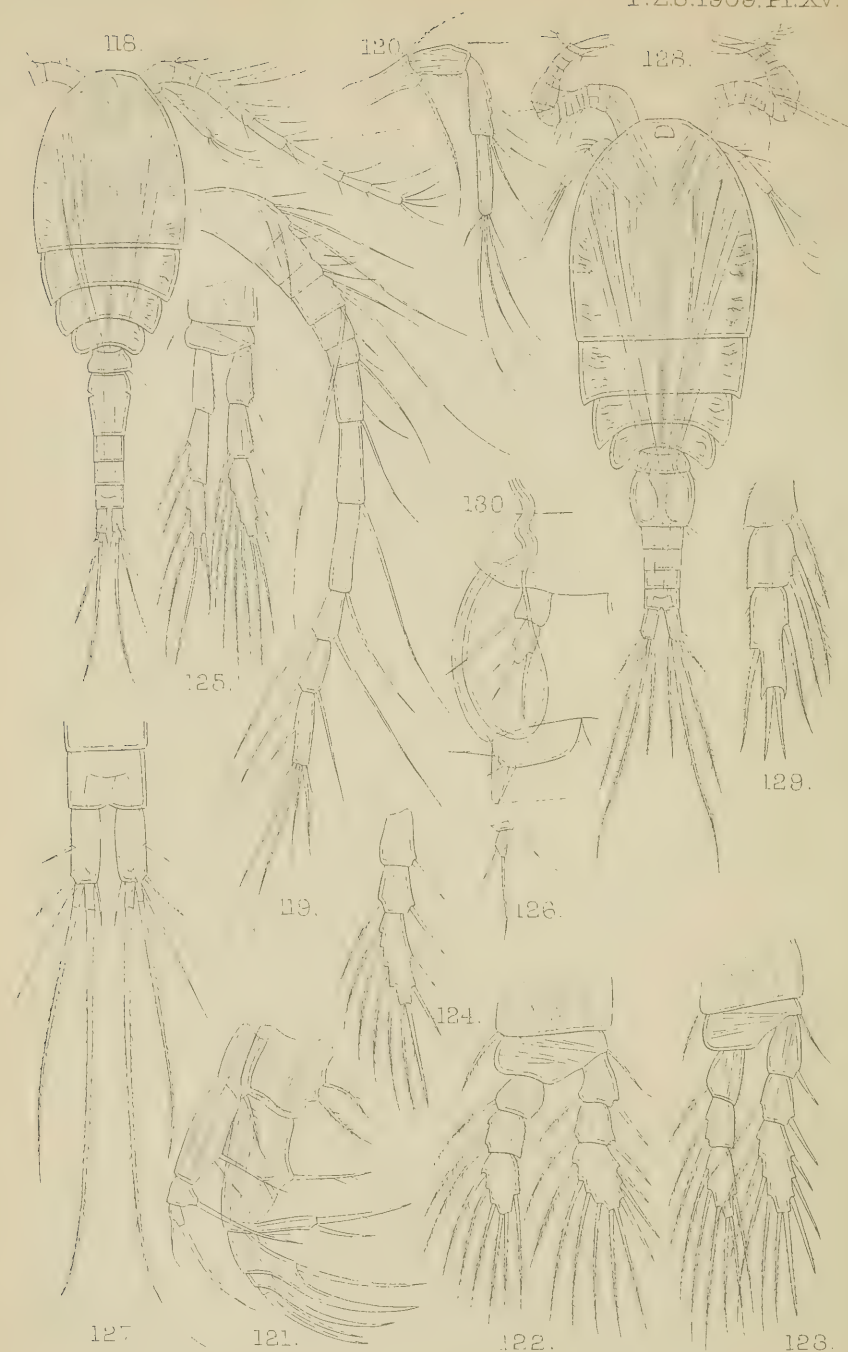
M.E.Parker lith.

87-92, SCHIZOPERA SCALARIS, G.O.Sars.
93-104, ILYOPHILUS PERPLEXUS, G.O.Sars.



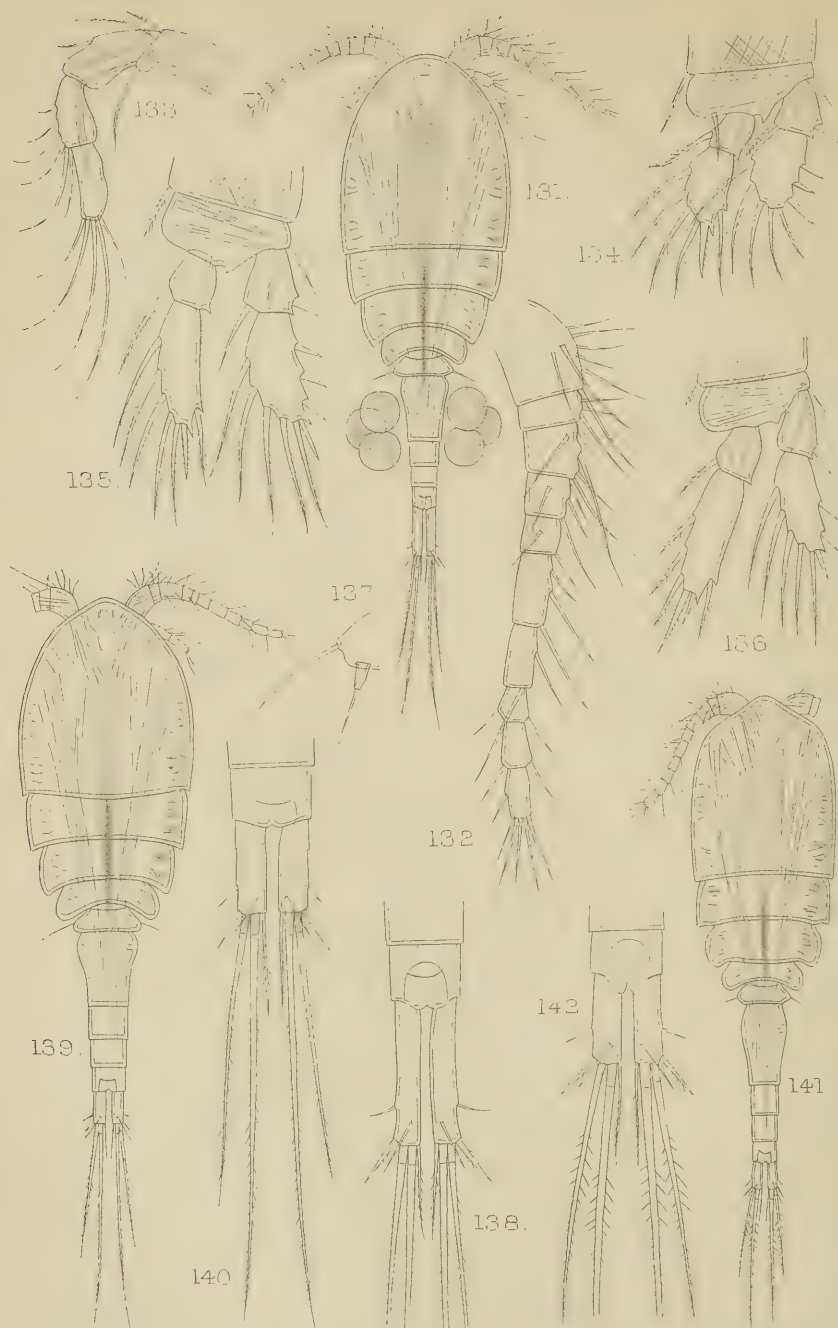
103-105. CYCLOPS FLAVIPES, G.O. Sars.
 106-108. CYCLOPS EMINI, Mrázek.
 109-111. CYCLOPS NEGLECTUS, G.O. Sars.

M.P. Becker lab.



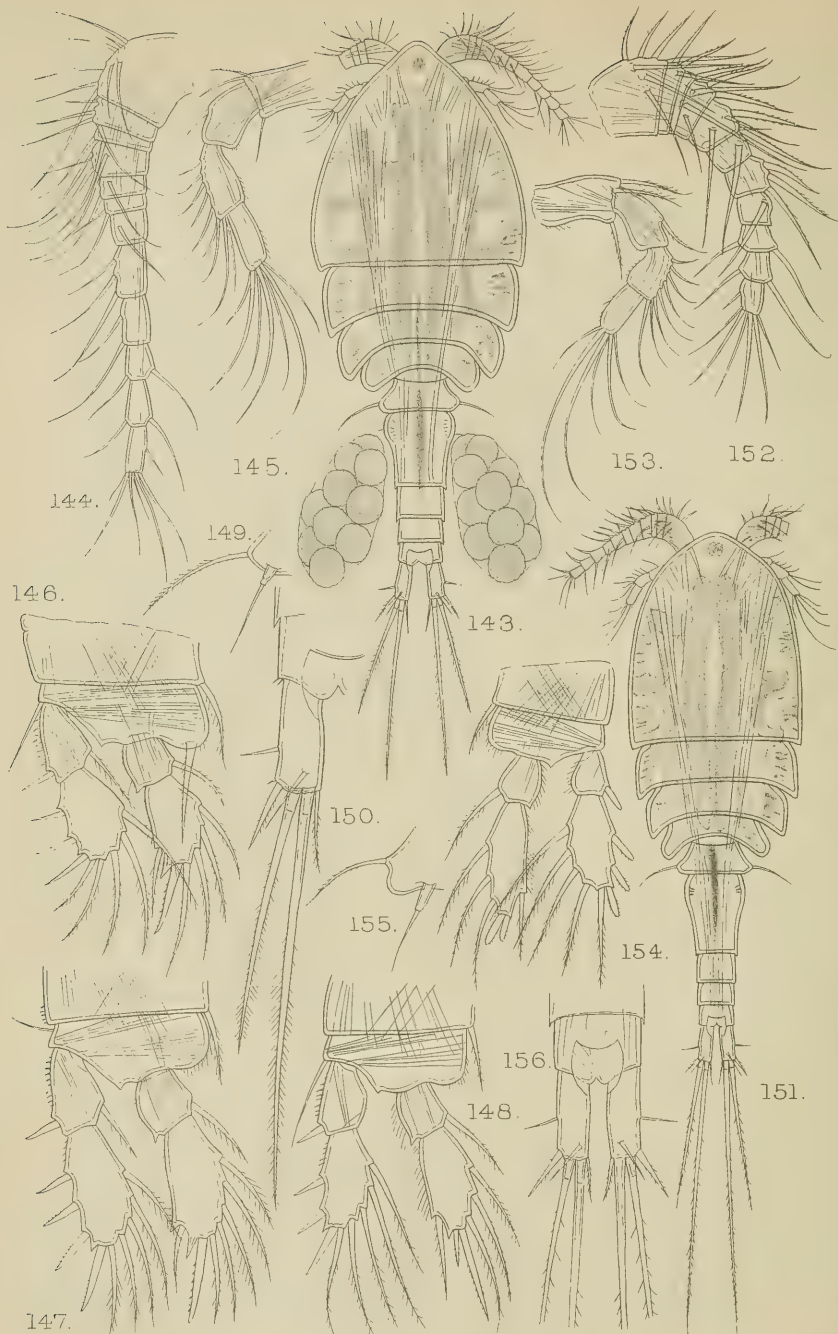
118-127. CYCLOPS PENNSYLVANICUS, G.O. Sars.
128-130. CYCLOPS ALBIDUS, (Germine).

M.P. Parker lith.



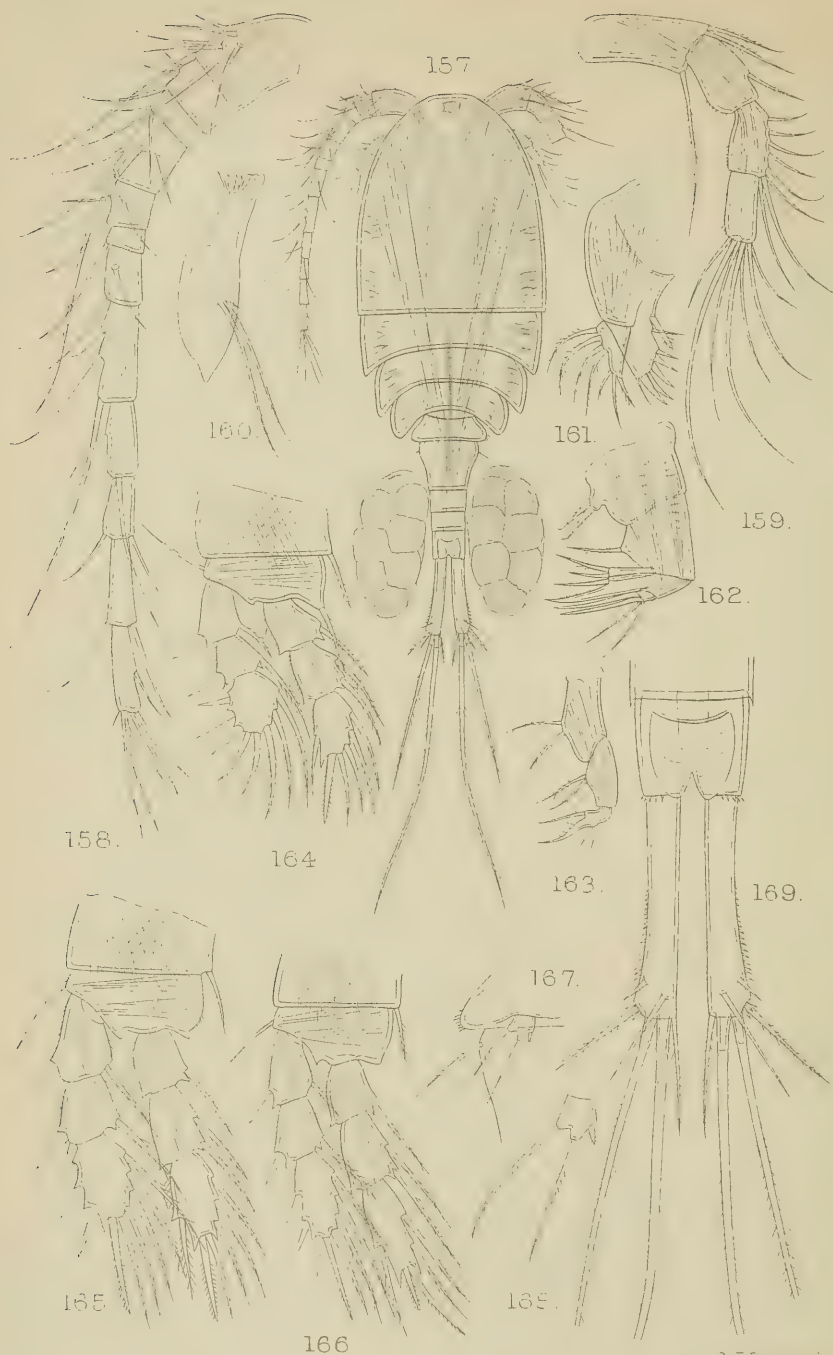
M.F. Feltz, sculp.

131-138, CYCLOPS ATTENUATUS, G.O. Sars.
 139, 140, CYCLOPS VARICANS, G.O. Sars.
 141, 142, CYCLOPS EXIGUUS, G.O. Sars.

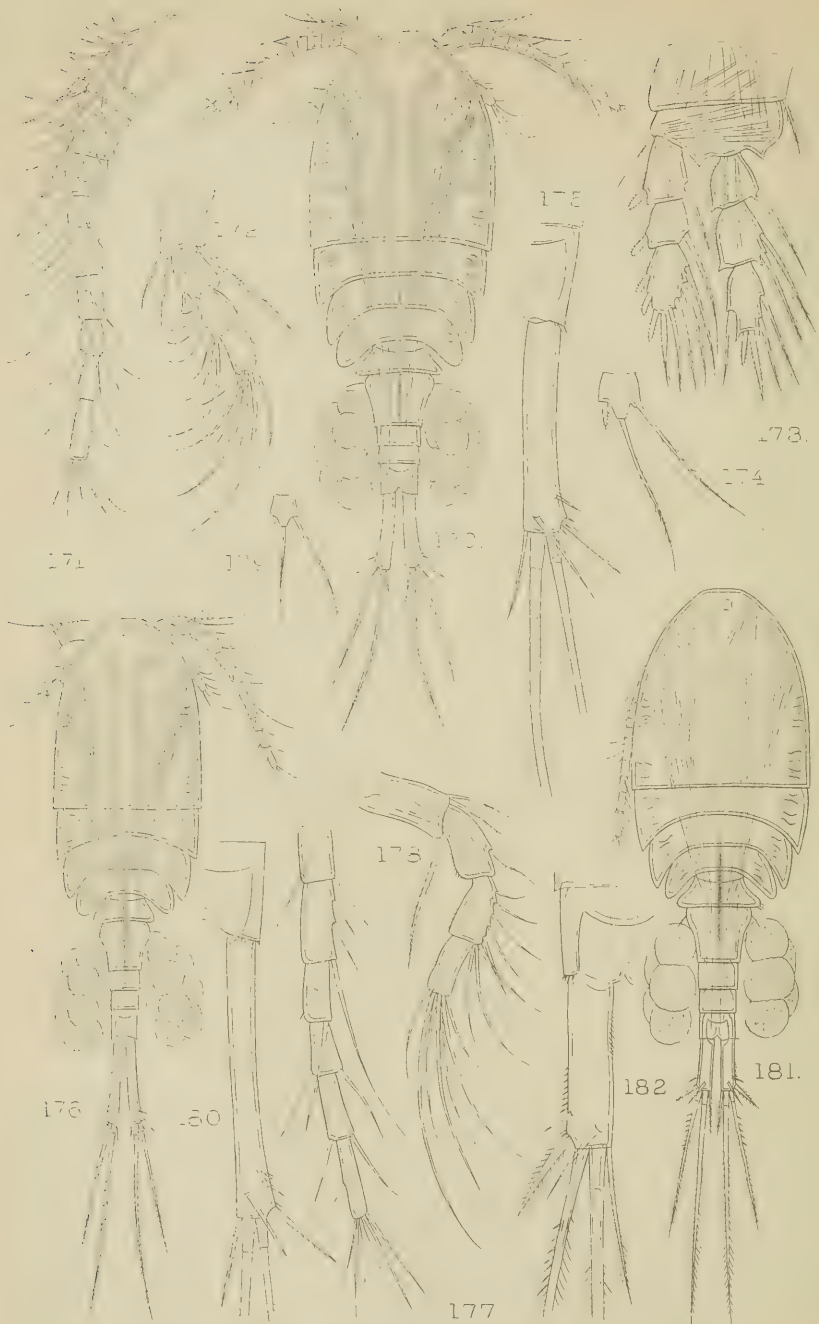


M.P. Parker lith.

143-150, *CYCLOPS CUNNINGTONI*, G.O. Sars.
151-156, *CYCLOPS PACHYCOMUS*, G.O. Sars

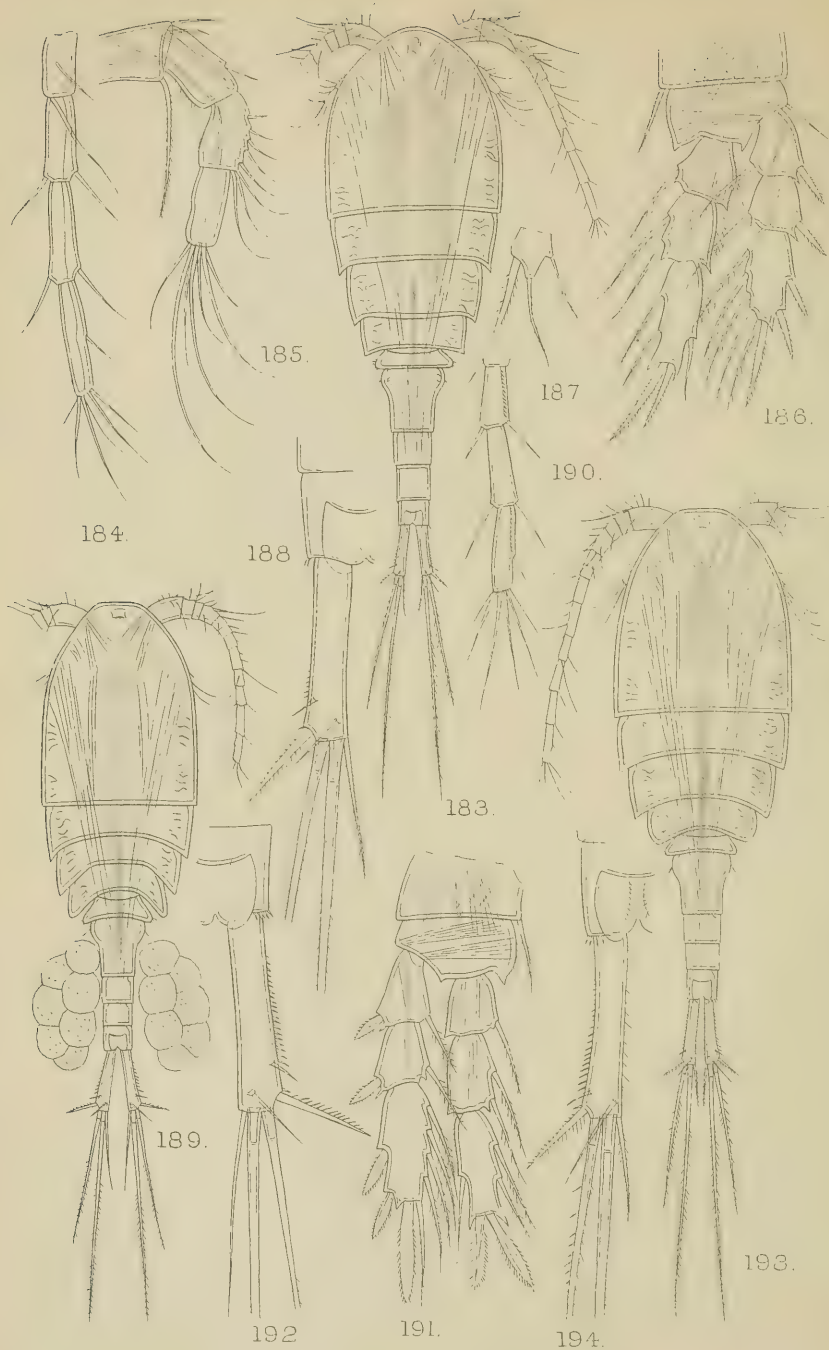


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M.P. Parker lith

170-175, CYCLOPS LAEVIMARGO, G.O. Sars.
 176-180, CYCLOPS ANCUSTUS G.O. Sars.
 181, 182, CYCLOPS RARISPINUS, G.O. Sars.

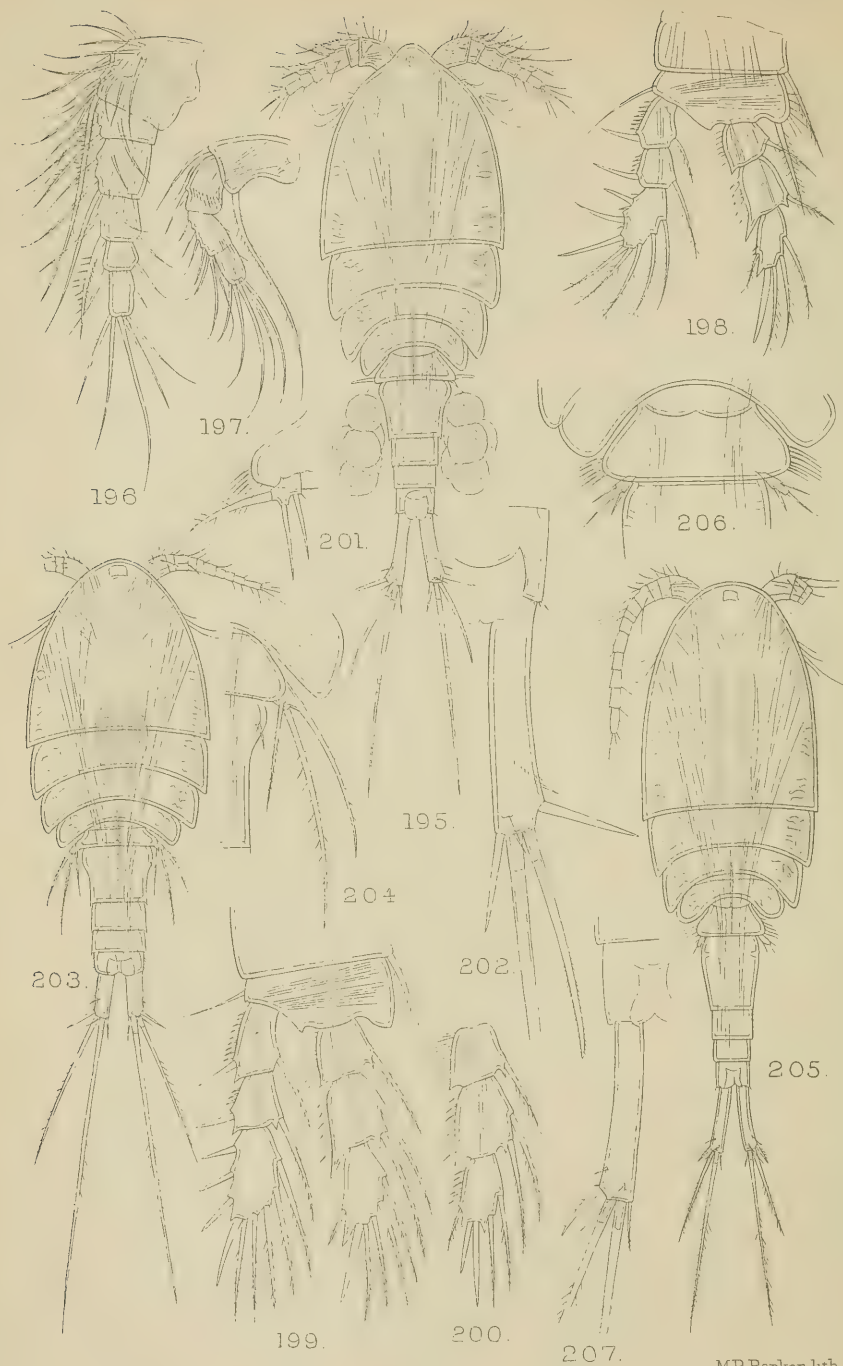


MPParker lith.

193-188, CYCLOPS AGILOIDES, G.O.Sars.

189-192, CYCLOPS EUACANTHUS, G.O.Sars.

193, 194, CYCLOPS CILIATUS, G.O.Sars.

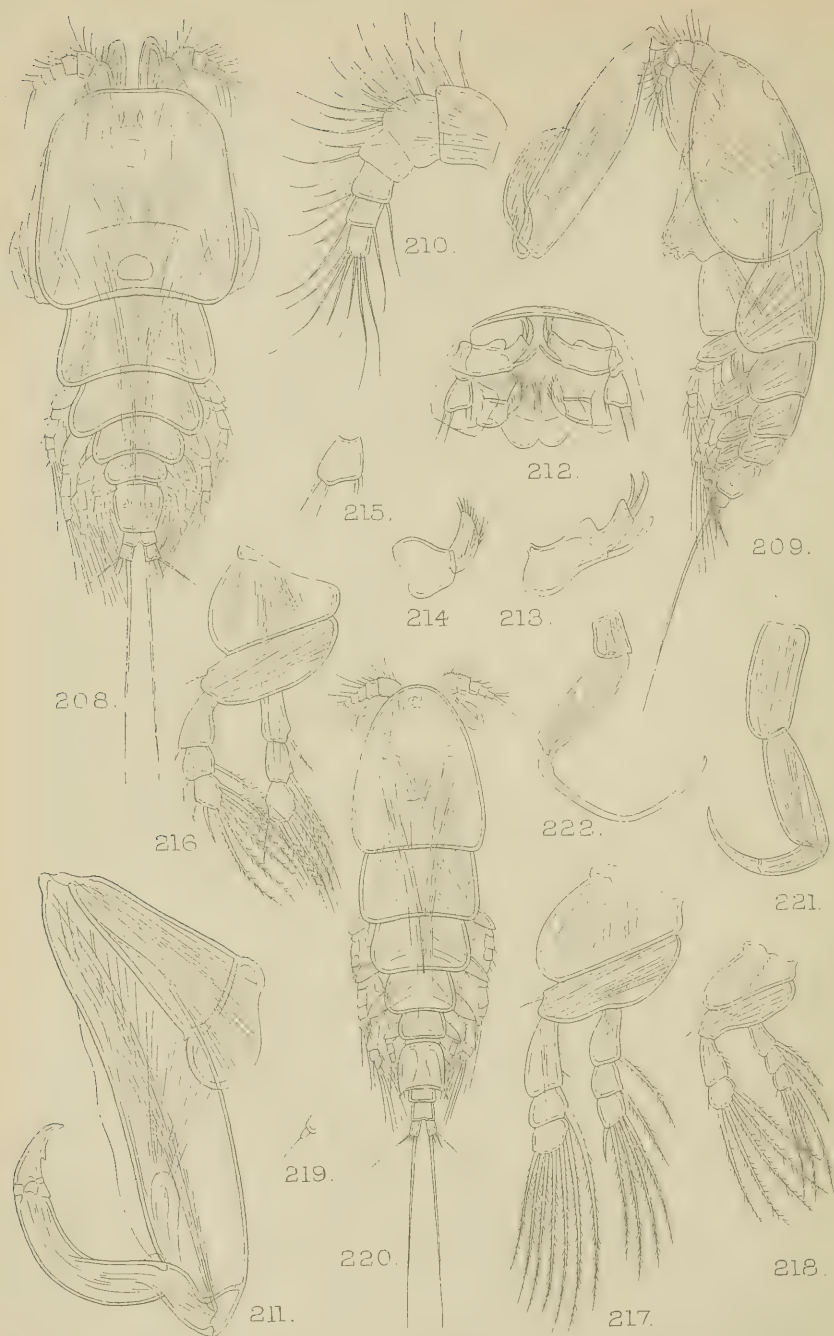


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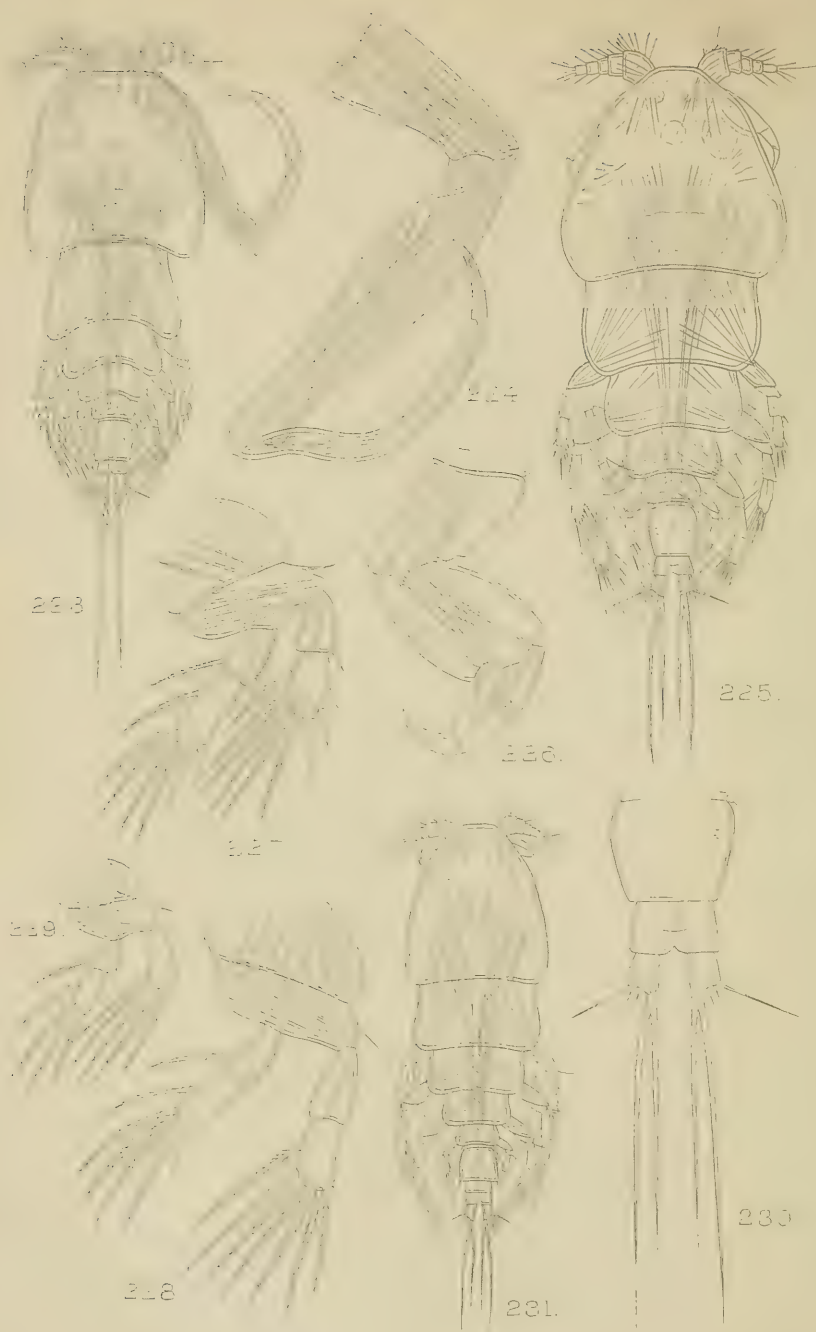
195-202, CYCLOPS OLIGARTHURUS, G.O.Sars.

203, 204, CYCLOPS COMPACTUS, G.O.Sars.

205-207, CYCLOPS DUBIUS, G.O.Sars



M.F. Parker del.



M. P. Parker lith.

223, 224, *ERGASILOIDES MACRODACTYLUS*. G.O. Sars.
 225-231, *ERGASILOIDES BREVIMANUS*. G.O. Sars.

- Figs. 94-104. *Trypanosoma percae*, from the Perch, all from preparations stained with iron-haematoxylin, except 94, 95, 103, 104. 97, 98, fixed with Schaudinn's fluid after previous exposure to osmic vapour; 98-102, fixed with Mann's picro-corrosive-formol; 103, osmic vapour followed by absolute alcohol, 104, dried off and fixed with absolute alcohol, both stained with Giemsa's stain.
- 94, 95. Sketch of *Trypanosoma percae*, large forms, drawn living; 94, a specimen showing two dots at the hinder end (kinetocore and blepharoplast?); 95, a specimen showing a refringent dot, lodged in a vacuole, close behind the trophocore.
96. Specimen showing myonemes on both surfaces of the body, from a preparation in which the stain was but slightly extracted.
97. Middle portion of another specimen, very contracted, showing myonemes, from the same preparation as the last.
98. Specimen showing a large blepharoplast, connected with the kinetocore (or division of the kinetocore?).
99. Another specimen from the same preparation as the last.
- 100-102. Trophocores of different specimens.
- 103, 104. Stout forms drawn to show the distribution of the cytoplasmic granules; in 104 many of the granules are in pairs, as if dividing or recently divided.

2. Zoological Results of the Third Tanganyika Expedition, conducted by Dr. W. A. Cunningham, F.Z.S., 1904-1905.—Report on the Copepoda. By Prof. G. O. Sars, C.M.Z.S.

[Received September 11, 1908.]

(Plates VI.-XXIII.)*

INTRODUCTION.

The Entomostracan fauna of the great inland waters of Central Africa is still very imperfectly known. Only one of the big lakes, viz., Victoria Nyanza, has been partly explored in this respect by German naturalists, the results being published in the great work 'Die Thierwelt Deutsch Ost-Afrikas,' whereas the other large lakes have remained almost entirely unexplored, so far as regards the Entomostraca. During the third Tanganyika Expedition the conductor, Dr. W. A. Cunningham, made collections not only in Victoria Nyanza, but also in two other lakes, viz., Nyasa and Tanganyika. The higher Crustacea contained in these collections have already been worked out and the results published in the present journal, for the Brachyura by Dr. Cunningham, for the Macrura by Dr. Calman. It has hereby been proved that Lake Tanganyika differs remarkably in its faunistic character from the other two lakes, and on the whole exhibits a much richer and more specialized fauna, as regards these two groups. Of course, it would be of great interest to know if an analogous difference also exists as regards the lower Crustacea or Entomostraca. Material for the solution of this question has fortunately been procured by Dr. Cunningham, who by the aid of more or less fine-meshed tow-nets has collected from each of the three lakes a number of samples chiefly taken at the

* For explanation of the Plates see p. 72.

surface, but in some cases so near the shores as also to contain some material from the bottom. At the request of Dr. Cunningham, I have undertaken the examination of these samples, and have been much interested in selecting from them the several forms of Entomostraca therein contained. The Cladocera have been sent back to Dr. Cunningham, who desired to report on that group himself, whereas the Copepoda and the Ostracoda will be worked out by me.

The material which has been placed in my hands for examination, consists of a large series of tubes containing samples carefully preserved in formalin, and exactly numbered, both as to date and locality. To these samples were added some few smaller tubes containing Copepoda and Ostracoda, selected by Dr. Cunningham from some of the larger tubes. The greatest number of samples are derived from Lake Tanganyika. There are, however, a sufficient number of samples also from the two other lakes for instituting a comparison of the Entomostracan fauna of all three lakes.

At the first sight, the samples looked rather unpromising, some of them being apparently quite devoid of Entomostraca, and others partly filled up with a compact muddy deposit which seemed quite unfit for investigation. Yet, by a very careful microscopical examination of all the tubes, I have succeeded in bringing to light a considerable number of different forms, both of Copepoda and Ostracoda, many of them apparently new to science. Some of the latter are of a quite particular interest, and will necessitate a renewed discussion about the origin of the fauna in the lakes. At the close of this Report some general remarks on this and other questions will be given.

Owing to the great number of new and imperfectly known forms found in the samples, and which need to be described and figured, I have found it appropriate to divide my Report into two parts, the one treating of the Copepoda, the other of the Ostracoda. To these will be added a smaller paper on some larval stages of prawns, mostly found in the samples from Lake Tanganyika. The present part of the Report is wholly devoted to the Copepoda, which is by far the most richly represented group of Crustacea in the lakes.

SYSTEMATIC NOTES AND DESCRIPTIONS OF NEW OR IMPERFECTLY KNOWN SPECIES.

The Copepoda found in the samples belong to the three leading divisions: Calanoida, Harpacticoida, and Cyclopoida. The first-named division, as is well known, contains forms which, as a rule, lead an errant or sub-pelagic life, and of course will chiefly characterise the surface-plankton of the lakes. On the other hand, the forms belonging to the second division are exclusively bottom-dwellers. The third division contains both planktonic and true bottom-forms.

I. CALANOIDA.

Of this division five species have been found in the collection, all of which belong to a single genus

Genus DIPTOMUS Westwood.

Of this genus, as is well known, a very great number of species have been described, chiefly distributed in the lakes of the northern hemisphere. South of the equator the genus *Boeckella* seems to replace *Diaptomus*, only a very limited number of species of the latter genus having hitherto been recorded, viz., 2 from Victoria Nyanza, 2 from the Cape Colony, 2 from Australia, and 6 from South America. Of the five species here recorded, two have been previously, though rather imperfectly, described, whereas the other three species are new to science. I give below short diagnoses of all the five species, and on the accompanying plates carefully-drawn habitus- and detail-figures of each.

1. DIPTOMUS GALEBOIDES, nom. nov. (Plate VI. figs. 1-8.)

Syn.: *Diaptomus galebi* Mrázek (not Barrois).

Specific Characters.—FEMALE. Body (figs. 1 & 2) moderately slender, with the anterior division oblong in form, slightly narrowed both in front and behind, the greatest width occurring anterior to the middle. Last segment of metasome not defined from the preceding one, except by a very slight notch on each side, lateral corners scarcely at all projecting, nearly rectangular, with a very small and delicate mucro at the tip (see figs. 3 & 4); inner part rounded off, without any mucro. Urosome (fig. 3) almost quite symmetrical, with the genital segment only very slightly dilated in front, and carrying on each side an extremely small and delicate, hair-like point. Last two segments imperfectly defined, and combined about half the length of the genital segment. Caudal rami comparatively short, with the marginal setae of quite normal appearance. Anterior antennae slender and elongated, when reflexed exceeding the body by the last 2 or 3 joints (see fig. 2). Last pair of legs (fig. 5) with the inner ramus quite short, not attaining half the length of the proximal joint of the outer; claw of the latter ramus of moderate size and finely ciliated inside; terminal joint only faintly defined at the base; inner apical seta extending beyond the tip of the claw. Ovisac (see fig. 1) comparatively small, and containing, as a rule, only four ova arranged regularly in pairs.

MALE (fig. 6) somewhat smaller than female and of more slender form. Last segment of metasome with the lateral corners simple, scarcely produced behind. Urosome narrow cylindric in form, 5-articulate. Right anterior antenna with the projection of the antepenultimate joint (see fig. 7) very small, not nearly attaining half the length of the penultimate joint, and scarcely at all curved at the tip; last joint without any hook at the end. Last pair of legs (fig. 8) somewhat resembling in structure those

in *D. galebi*, though, on a closer comparison, differing in some particulars. Right leg with the 2nd basal joint produced at the end, on the posterior face, to a short, somewhat falciform incurved lamella, inner edge perfectly smooth; proximal joint of outer ramus terminating outside in an obtuse corner; distal joint pyriform in shape, with a very delicate scale-like projection on the posterior face, about in the middle between the apical claw and the lateral spine, the latter attached much nearer to the base than to the end of the joint; apical claw much curved and finely denticulated inside for some part of its length. Left leg with the outer ramus distinctly biarticulate and terminating in a well defined digit accompanied by a small ciliated bristle; inner edge divided into two rounded and finely ciliated lobules.

Length of adult female 1.30 mm.

Remarks.—This form has been identified by Dr. Mrázek with the Egyptian species, *D. galebi* Barrois, apparently owing to a certain similarity in the structure of the last pair of legs in the two sexes. I find, however, that the present form differs in so many other points from the above-named species, as more fully described by Dr. Richard*, that I have felt justified in regarding it as specifically distinct, though nearly related to *D. galebi*. The specific name here proposed alludes to this near relationship of the two species.

Occurrence.—This form occurred in great abundance in a sample taken 25/4/05 off the island Bukoba, western shore of Victoria Nyanza. The same species has also been recorded previously by Dr. Mrázek and Dr. von Daday from other localities, and seems indeed to be one of the most characteristic plankton-forms of that lake. Together with the usual form, there also occurred in the same sample a much smaller variety of somewhat more slender body and with the anterior antennæ more elongated, but otherwise agreeing in all structural details exactly with the larger form.

2. DIAPTOMUS MIXTUS, sp. n. (Plate VII. figs. 9–17.)

Specific Characters.—FEMALE. Body (figs. 9 & 10) comparatively more slender than in the preceding species, with the anterior division narrow oblong in form and having its greatest width about in the middle. Last segment of metasome, as in *D. galeboides*, confluent with the preceding one, but having the lateral corners distinctly projecting, each armed with two well-defined, sharply-pointed mucros (see fig. 11), the one issuing somewhat more dorsally. Urosome conspicuously asymmetrical, its terminal part being more or less turned to left side; genital segment (fig. 11) gradually widening in front, and armed on each side with a small, though distinct mucro; last two segments confluent, and combined not attaining half the length of the genital segment. Caudal setæ normal. Anterior antennæ very slender

* Revue biologique du nord de la France, tome v. 1892–93.

and elongated, when reflexed exceeding the body by the last three joints. Last pair of legs (fig. 12) rather short and stout; inner ramus about half the length of the proximal joint of the outer; claw of the latter ramus smooth inside; terminal joint very small, with the inner apical seta not extended beyond the tip of the claw.

MALE (fig. 13) with the lateral corners of last segment of metasome produced backwards and each tipped with a well defined mucro, the right one more prominent than left. Urosome very slender and more or less turned to right side. Right anterior antenna (fig. 14) with the middle section rather dilated; terminal section, as usual, composed of four joints, the antepenultimate one produced at the end anteriorly to a rather strong hook-like projection (fig. 15) considerably exceeding half the length of the penultimate joint. Last pair of legs (fig. 16) rather strongly built; right leg with the 2nd basal joint produced at the end, on the posterior face, to a short and broad, securiform plate projecting into three angular corners (fig. 17); inner ramus extremely small and rudimentary; outer ramus with the proximal joint short and obtusely produced outside; distal joint very large, oblong, pyriform in shape, and so attached that it forms nearly a right angle with the axis of the leg; scale-like projection of posterior face occurring just inside the lateral spine, the latter rather slender and attached close to the base; apical claw strong and much curved. Left leg of a similar structure to that in *D. galeboides*.

Length of adult female 1.55 mm.

Remarks.—In the general appearance, the distinctly developed mucros on the last segment of the metasome, and the conspicuously asymmetrical urosome, this form much more resembles *D. galebi* than does the preceding species. Yet it is quite certainly distinct from both these species, as proved by the rather different structure of the last pair of legs, especially in the male. The somewhat mixed characters of this species have given rise to the specific name here proposed.

Occurrence.—A single adult female and some few male specimens of this form were picked up from a sample taken 13/6/04 in Anchorage Bay, southern end of Lake Nyasa. The sample contained a considerable quantity of a dark muddy deposit, and thus has apparently been taken from very shallow water. A few not fully adult specimens of the same species occurred also in another sample taken 11/6/04 in that bay.

3. *DIAPTOMUS STUHLMANNI* Mrázek. (Plate VIII. figs. 18–24.)

Diaptomus stuhlmanni Mrázek, Die Copepoden Ost-Afrikas, p. 7, pl. iii. figs. 1–3, 6, 7.

Specific Characters.—FEMALE. Body (figs. 18 & 19) comparatively short and stout, with the anterior division somewhat dilated in front, the greatest width occurring across the cephalic segment. Last segment of metasome, as in the two preceding

species, confluent with the preceding one; lateral corners rather projecting, and each terminating in a strong mucro pointing outwards (fig. 20). Urosome comparatively short and perfectly symmetrical; genital segment nearly of equal width throughout and without any distinct lateral mucros; last two segments confluent, and combined not nearly attaining half the length of the genital segment. Caudal rami and setae normal. Anterior antennae, when reflexed, scarcely extending beyond the tip of the caudal rami. Last pair of legs (fig. 21) with the inner ramus more produced than in the two preceding species, considerably exceeding half the length of the proximal joint of the outer, and tipped with two slender setae; claw of outer ramus of moderate size and quite smooth; terminal joint imperfectly defined at the base, inner apical seta extending to the tip of the claw. Ovisac comparatively small, with a somewhat varying number of ova (from two to eight).

MALE with the antepenultimate joint of right anterior antenna produced at the end to a slender mucroniform process nearly as long as the penultimate joint (fig. 22). Last pair of legs (fig. 23) with the squamiform expansions of 1st basal joint simple, not spiniferous; 2nd basal joint of right leg without any projection at the end; proximal joint of outer ramus terminating outside in an obtuse corner; distal joint oblong oval in form, with a small scale-like projection on the posterior face just inside the lateral spine, the latter of moderate size and attached about in the middle of the outer edge; apical claw about twice the length of the distal joint and somewhat curved in the middle. Left leg with the outer ramus uniaarticulate and somewhat spoon-shaped, terminating in a small digit accompanied by a short ciliated bristle; inner edge evenly curved and finely denticulated; anterior face with a small ciliated lobule not projecting beyond the inner edge (fig. 24).

Length of adult female 1.12 mm.

Remarks.—This form has been described, though rather imperfectly, under the above name by Dr. Mrázek in the above quoted paper. It is nearly allied to the two preceding species, but evidently specifically distinct, being especially distinguished by the short and stout form of the body, the projecting lateral corners of the last segment of the metasome, and the structure of the last pair of legs in both sexes.

Occurrence.—This form occurred rather plentifully together with *D. galeoides* in the above-mentioned sample from Victoria Nyanza. It was also found in another sample from the same lake, taken 20/4/05 in about the same region. Dr. Mrázek records it also from the island Djume.

4. DIAPTOMUS SIMPLEX, sp. n. (Plate VIII. figs. 25–32.)

Specific Characters.—FEMALE. Body (figs. 25 & 26) rather short, with the anterior division regularly oblong-oval in form, gradually narrowed both in front and behind. Last segment of metasome

(see fig. 27) wholly coalesced with the preceding one, and having the lateral parts quite simple, not expanded laterally, each with a very delicate hair-like point on the outer edge (fig. 28). Urosome (fig. 27) rather slender and narrow, and perfectly symmetrical; genital segment slightly widening in front and without any lateral mucros; the last two segments confluent, and combined fully half the length of the genital segment. Caudal rami somewhat more produced than in the three preceding species; marginal setæ normal. Anterior antennæ slender and elongated, when reflexed exceeding the body by the last two joints (see figs. 25 & 26). Last pair of legs (fig. 29) comparatively large; inner ramus somewhat exceeding half the length of the proximal joint of the outer and finely ciliated on the tip; claw of this ramus comparatively short and thick; terminal joint extremely minute, nodiform, with the inner apical seta not extended to the tip of the claw. Ovisac rather large, broadly rounded in form, and containing a greater number of ova than in any of the preceding species.

MALE with the antepenultimate joint of right anterior antenna (fig. 30) produced at the end to a slender spiniform process slightly curved at the tip, and fully as long as the penultimate joint. Last pair of legs (fig. 31) with the squamiform expansions of 1st basal joint, as in *D. stuhlmanni*, simple, not spiniferous; 2nd basal joint of right leg without any projection at the end; proximal joint of outer ramus terminating outside in an obtuse corner; distal joint broadly oval in form and without any scale-like projection of the posterior face; lateral spine comparatively short and attached much nearer to the end than the base of the joint; apical claw of moderate size and only slightly curved. Left leg with the outer ramus pronouncedly spoon-shaped and unarticulate, inner edge evenly curved and minutely spinulose; terminal digit very small and partly concealed, accompanying bristle likewise small; anterior face of the ramus provided with a small linguiform lamella, finely ciliated at the edge (see fig. 32).

Length of adult female 1.10 mm.

Remarks.—This is a rather small species, and is prominently distinguished not only from the four preceding species, but also from most other known Diaptomi, by the simple, not expanded lateral parts of the last segment of metasome in the female; hence the specific name here proposed.

Occurrence.—This form occurred rather abundantly in two of the samples from Tanganyika, the one taken 18/11/04 off Kala, eastern shore of the lake, the other 1/3/05 off Kaboge, north-western shore. It was also found occasionally in some other samples, and seems indeed to be one of the most characteristic plankton-forms of that lake.

5. *DIAPTOMUS CUNNINGTONI*, sp. n. (Plate IX. figs. 33–42.)

Specific Characters.—FEMALE. Body (figs. 33 & 34) comparatively short and stout, with the anterior division somewhat

dilated in its anterior part and but slightly narrowed behind. Last segment of metasome (see fig. 35) confluent with the preceding one, and having the lateral parts conspicuously expanded, each terminating in an acutely produced corner pointing outwards, their posterior edge being boldly rounded off and without any mucro (figs. 36 & 37); left expansion a little larger than right. Urosome (fig. 35) comparatively short, with the genital segment slightly asymmetrical and almost of uniform width throughout; last two segments confluent, and combined not attaining half the length of the genital segment. Caudal rami short, with the marginal setæ normal. Anterior antennæ (see figs. 33 & 34) remarkably short, when reflexed scarcely extending beyond the middle of the genital segment. Last pair of legs (fig. 38) with the inner ramus rather produced, extending almost to the end of the proximal joint of the outer, and tipped with two slender setæ; claw of the latter ramus comparatively short and smooth inside; terminal joint very small and imperfectly defined at the base, its inner apical seta not extending as far as the claw.

MALE (fig. 39) with the lateral corners of the last segment of metasome produced backwards, that on right side the more prominent, each tipped with a delicate, hair-like mucro. Antepenultimate joint of right anterior antenna (fig. 40) produced at the end to a strong spiniform process extending to the end of the succeeding joint. Last pair of legs (fig. 41) with the squamiform expansions of 1st basal joint each tipped with a slender hair-like spine; right leg with the 2nd basal joint simple, without any projection at the end; proximal joint of outer ramus produced at the outer corner to an acute spiniform process; distal joint oval in form and provided on the posterior face, somewhat in front of the middle, with a slightly curved spiniform projection; lateral spine comparatively short and attached near the end of the joint; apical claw rather strong, and abruptly curved in the middle. Left leg with the outer ramus pronouncedly spoon-shaped and unarticulate; inner edge evenly curved and fringed with short hairs; apical digit very short and obtuse at the tip; anterior face of the ramus hollowed and provided with a delicate ciliated lappet not projecting beyond the inner edge (fig. 42).

Length of adult female 1.25 mm.

Remarks.—This form is at once distinguished from the other four species here described by the shortness of the anterior antennæ. Moreover, several well-marked differences are found in the other structural details, as pointed out in the above diagnosis. I have much pleasure in naming this distinct species in honour of the distinguished conductor of the Expedition.

Occurrence.—This species is peculiar to Lake Nyasa. I have found it very abundantly in three of the samples from that lake, one of them being taken 17/6/04 in Monkey Bay, the other two off Karonga, north end of the lake.

II. HARPACTICOIDA.

The forms of this division found in the collection belong to two distinct genera, both of which have hitherto been regarded as strictly marine. Each of these genera belongs to a separate family, the one to the Diosaccidæ, the other to the Cletodidæ, both families represented in the sea by numerous genera and species.

Family DIOSACCIDÆ.

One of the most prominent characters of this family, as indicated by the name, is the presence in the female of two ventral ovisacs, a feature very seldom met with in the Harpacticoida, and not found in any of the hitherto described fresh-water forms, which, like the great majority of marine forms, have only a single ovisac. Indeed, this character was formerly regarded as peculiar to the whole division, in contradistinction to the Cyclopoida, where constantly two ovisacs are present in the female. The present family comprises as yet about five distinct genera.

Genus SCHIZOPERA G. O. Sars.

Generic Characters.—Body more or less slender, cylindric in form, with no sharp demarcation between the anterior and posterior divisions. Cephalic segment of moderate size and provided in front with a well-developed rostrum, distinctly defined at the base, and generally of narrow lanceolate form. Epimeral plates of the three succeeding segments rounded. Last pedigerous segment without true epimeral plates. Urosome scarcely narrower than the anterior division; genital segment in female imperfectly divided in the middle. Caudal rami more or less produced, generally somewhat lamellar, each with a strong spine outside accompanied by a slender seta, and with another delicate seta arising from the upper face; tip truncated and carrying three setæ, the innermost extremely small, the outermost much shorter than the middle one, which generally is very strongly developed. Anterior antennæ in female comparatively short, 8-articulate; 4th joint somewhat produced at the end and carrying a slender band-like sensory appendage, terminal part consisting of four joints, the last much the longest; those in male hinged in the usual manner. Posterior antennæ comparatively short and stout, geniculate; outer ramus small, biarticulate. Mandibles with the palp well developed, biramous. Maxilla and maxillipeds of usual structure. First pair of legs more or less distinctly prehensile; outer ramus 3-articulate, and generally shorter than the inner; the latter somewhat varying in structure in the different species, consisting of three or only two joints, the first of which is the largest and provided inside at some distance from the end with a strong ciliated seta. Natatory legs, as a rule, very slender, with both rami 3-articulate and provided inside with a very limited number of spiniform setæ; inner ramus of 2nd pair of

legs in male transformed, carrying near the tip outside a strong spiniform appendage. Last pair of legs comparatively small, distal joint with generally six very unequal and partly spiniform marginal setæ, inner expansion of proximal joint rather short and provided with four spiniform setæ; these legs in male, as usual, still smaller and with the number of setæ reduced. Ovisacs in female narrow and closely juxtaposed, each containing a very limited number of ova, in some cases arranged in a single row.

Remarks.—This genus was established by the present author in the year 1905*, to comprise a species, *S. longicauda* G. O. Sars, found in a brackish lagoon on the Chatham Islands. It was, however, subsequently† withdrawn, as I found it somewhat difficult to distinguish it exactly from the much diversified genus *Amphiascus* G. O. Sars. Having, however, now become acquainted with a number of new species agreeing with that originally observed in the more essential characters, I am disposed to restore the present genus, which seems to form a quite natural group. None of the Norwegian species of *Amphiascus* can properly be referred to it. On the other hand, a well-marked species occurs in the Caspian Sea, and another species I have recently found in a sample from the brackish lake, Birket el Qurun, in Egypt. In the present collection I have determined no less than eight different species, to be described below.

6. SCHIZOPERA INOPINATA, sp. n. (Plate X. figs. 43–58.)

Specific Characters.—FEMALE. Body (figs. 43 & 44) moderately slender and of the usual subcylindric form, with the anterior division longer than the posterior. Rostrum (see fig. 45) rather prominent, narrow lanceolate in form, and somewhat curved at the tip. Last caudal segment (see fig. 55) shorter than the preceding one, and having the anal opercle very small and perfectly smooth. Caudal rami about the length of that segment and rather divergent, being gradually narrowed distally, inner edge straight and very finely ciliated; spine of outer edge attached about in the middle, dorsal seta somewhat nearer the tip, the latter narrowly truncated and armed above the insertion of the apical setæ with a transverse row of four small denticles. Anterior antennæ (see fig. 45) comparatively slender, though not nearly attaining the length of the cephalic segment. Posterior antennæ (fig. 46) remarkably short and stout, with the outer ramus (fig. 47) very narrow. Oral parts (figs. 48 & 49) of the structure characteristic of the genus. First pair of legs (fig. 50) with the outer ramus about the length of the 1st joint of the inner, and having the last joint considerably longer than the other two; inner ramus distinctly 3-articulate, with the last two joints incurved and combined scarcely attaining half the length of the 1st; last joint armed at the tip with a slender claw-like spine and two unequal

* Zool. Jahrbücher, Bd. xxi. Heft 4, p. 383.

† Account of the Crustacea of Norway, vol. v. p. 148.

setæ. Natatory legs (figs. 51-53) with no seta inside the 1st joint of the rami. Last pair of legs (fig. 54) with the distal joint oval quadrangular in form, proximal seta of outer edge rather strong and spiniform, innermost seta but one likewise strongly developed; inner expansion of proximal joint somewhat narrowed and extending to about the middle of the distal joint. Ovisacs narrow oblong, with the ova partly arranged in a single row.

MALE with the anterior antennæ (fig. 56) distinctly hinged. Inner ramus of 2nd pair of legs (fig. 57) transformed in the usual manner. Last pair of legs (fig. 58) very small, with only four setæ on the distal joint and two setæ on the end of the inner expansion of proximal joint.

Length of adult female 0.45 mm.

Remarks.—This was the first species which came to my sight, and I have therefore given to it the above specific name. From the typical species, *S. longicauda*, it is easily distinguished by the comparatively shorter urosome and the somewhat different shape of the caudal rami. Moreover, there are some differences to be found in the structure of the legs. The present species is also rather inferior in size.

Occurrence.—This form was found occasionally in two of the samples from Tanganyika, the one taken 28/9/04 at Mbete, south end of the lake, the other, 13/10/04, at Sumbu, south-western border.

7. SCHIZOPERA VALIDIOR, sp. n. (Plate XI. figs. 59-63.)

Specific Characters.—FEMALE. Body (fig. 59) on the whole more strongly built than in the preceding species, with the integuments of coarser consistency. Rostrum somewhat less produced, but of a similar narrow lanceolate form. Caudal rami (fig. 63) rather large and broad, pronouncedly lamellar, and of oval form, less divergent than in *S. inopinata*; inner edge distinctly curved and densely hairy, spine of outer edge somewhat shorter than in that species, and attached much nearer to the end than to the base of the ramus; dorsal seta, on the other hand, issuing rather in front of the middle; end of the ramus without any denticles above. Anterior antennæ (fig. 61) of a similar structure to that in *S. inopinata*, though perhaps a little shorter. Posterior antennæ less robust. First pair of legs (fig. 61) with the outer ramus about as in the last-mentioned species, inner ramus distinctly 3-articulate; 1st joint not fully as long as the outer ramus, the last two joints comparatively more elongated than in *S. inopinata*, and combined considerably exceeding half the length of the 1st; last joint, as in that species, armed on the tip with a slender claw-like spine and two unequal setæ. Natatory legs with a well-developed seta inside the 1st joint of the inner ramus in the two posterior pairs. Last pair of legs (fig. 62) with the distal joint of a more regular oval form than in *S. inopinata* and somewhat conically produced at the tip; proximal seta of outer edge very long and abruptly deflexed; innermost seta but

one likewise more elongated than in that species; inner expansion of proximal joint comparatively larger, extending somewhat beyond the middle of the distal joint. Ovisacs (see fig. 59) broader than in that species, and containing a greater number of ova arranged in a double row.

Length of adult female 0.49 mm.

Remarks.—This form is closely allied to *S. inopinata*, but of somewhat larger size and more robust form of body. It also differs somewhat in the shape of the caudal rami and in the structure of the legs, as indicated in the above diagnosis.

Occurrence.—Only a single female specimen of this form has come to my notice. It was found in one of the two samples in which the preceding species occurred, viz., that from Sumbu.

8. SCHIZOPERA CONSIMILIS, sp. n. (Plate XI. figs. 64–67.)

Specific Characters.—FEMALE. Body (fig. 64) considerably more slender than in the two preceding species, and somewhat attenuated behind. Rostrum about as in *S. validior*. Urosome almost attaining the length of the anterior division, last segment somewhat shorter and narrower than the preceding one and having the anal aperture smooth. Caudal rami (fig. 67) considerably produced, exceeding in length the anal segment, and rather divergent, being nearly of uniform width throughout, inner edge straight and finely ciliated, spine of outer edge attached much nearer to the end than to the base of the ramus; dorsal seta likewise issuing somewhat behind the middle; tip transversely truncated and armed above the insertion of the apical setae with a transverse row of about seven small denticles. Antennae about as in *S. validior*. First pair of legs (fig. 65) comparatively shorter and stouter; outer ramus with the last joint shorter than the other two; inner ramus distinctly 3-articulate, with the 1st joint a little longer than the outer ramus, last two joints comparatively short, and combined scarcely attaining one-third of the length of the 1st; last joint, as in the two preceding species, armed with a slender claw-like spine and two unequal setae. Natatory legs of a similar structure to those in *S. validior*. Last pair of legs (fig. 66) with the distal joint comparatively small, rounded oval in form; marginal setae about as in *S. validior*; inner expansion of proximal joint rather short, not extending to the middle of the distal joint. Ovisacs oblong in form, with the ova arranged in a double row.

Length of adult female 0.51 mm.

Remarks.—This is perhaps the form which comes nearest to the typical species, *S. longicauda*. On a closer comparison it is, however, found to differ in some particulars, for instance in the shape of the caudal rami, and also somewhat in the structure of the legs, proving it to be in reality specifically distinct.

Occurrence.—Some few specimens of this form were found, partly in the same sample in which *S. validior* occurred, partly in another sample from Tanganyika, taken 29/10/04 in Vua

Harbour, western shore of the lake. Finally a single female specimen was found in the above-mentioned sample from Victoria Nyanza.

9. SCHIZOPERA UNGULATA, sp. n. (Plate XI. figs. 68-71.)

Specific Characters.—FEMALE. Body (fig. 68) rather slender, sublinear in form or very slightly attenuated behind. Rostrum long and prominent. Last caudal segment a little shorter than the preceding one, but scarcely narrower; anal opercle very small and perfectly smooth. Caudal rami (fig. 71) rather large and broad, conspicuously lamellar and somewhat divergent; inner edge curved and densely hairy; spine of outer edge attached nearer to the end than to the base of the ramus; dorsal seta originating about in the middle; end narrowly truncated and without any denticles above. Anterior antennæ rather slender, but of usual structure. First pair of legs (fig. 69) with the outer ramus comparatively short and stout, having the last joint longer than the others; inner ramus strongly built, but only composed of two joints, the 1st considerably longer than the outer ramus and slightly curved, the 2nd quite short and abruptly incurved, carrying on the tip a strong claw and a comparatively short seta, accompanied by a small hair-like bristle. Natatory legs rather strongly built, but scarcely differing in their structure from those in the two preceding species. Last pair of legs (fig. 70) with all the marginal setæ, except that issuing from the tip of the distal joint, remarkably strong and spiniform, being also much shorter than in the three preceding species; inner expansion of proximal joint extending almost to the tip of the distal joint.

Length of adult female 0.50 mm.

Remarks.—This species is chiefly distinguished from the preceding ones by the rather different structure of the 1st pair of legs, the inner ramus of which is composed of only two joints and is more prominently prehensile than in those species. It also differs somewhat in the shape of the caudal rami and the structure of the last pair of legs.

Occurrence.—Only a single specimen of this form, a female with well developed ovaria, but without ovisacs, has come to my notice. It was found in the same sample in which *S. validior* occurred.

10. SCHIZOPERA MINUTICORNIS, sp. n. (Plate XII. figs. 72-77.)

Specific Characters.—FEMALE. Body (fig. 72) very slender and narrow, sublinear in form, with the posterior division fully as long as the anterior. Rostrum (see fig. 73) acutely produced. Last caudal segment a little shorter and narrower than the preceding one; anal opercle very small and quite smooth. Caudal rami (fig. 77) pronouncedly lamellar and of oval form, being only slightly divergent; inner edge evenly curved and very finely ciliated, spine of outer edge not very strong and attached at a

short distance from the end of the ramus; dorsal seta issuing about in the middle, apical setæ comparatively short. Anterior antennæ (see fig. 73) unusually small, though composed of the normal number of joints. First pair of legs (fig. 74) with the outer ramus of normal structure; inner ramus almost twice as long, but composed of only two joints of about equal length, the distal one linear in form and scarcely at all incurved, carrying on the tip a slender claw-like spine and a single still more slender seta. Natatory legs (fig. 75) with the seta at the inner corner of the terminal joint of outer ramus very small and rudimentary; 1st joint of inner ramus in 2nd pair of legs without any seta inside. Last pair of legs (fig. 76) with the distal joint comparatively short, rounded oval in form, marginal setæ of the usual appearance; inner expansion of proximal joint extending about as far as the distal joint.

Length of adult female 0.46 mm.

Remarks.—This species is at once distinguished by the unusually small anterior antennæ, a character which has given rise to the specific name here proposed. It also can be distinguished by the anomalous structure of the 1st pair of legs.

Occurrence.—Of this form also only a solitary specimen has come to my notice, a fully grown female with well-developed ovaria, but without ovisacs. It was found in the same sample as the preceding species.

11. SCHIZOPERA SPINULOSA, sp. n. (Plate XII. figs. 78–81.)

Specific Characters.—FEMALE. Body (fig. 78) not particularly slender, with the posterior division much shorter than the anterior and slightly tapering behind. Rostrum of the usual shape. Last caudal segment somewhat shorter than the preceding one, and exhibiting above, on each side of the anal area, an oblique row of about five small spinules; anal opercle perfectly smooth. Caudal rami (fig. 81) broadly oval in form and pronouncedly lamellar; inner edge evenly curved and armed with a row of slender spinules continued across the end of the ramus above the insertion of the apical setæ; spine of outer edge rather strong and attached at a short distance from the end; dorsal seta issuing at about the middle. Anterior antennæ comparatively slender and of quite normal structure. First pair of legs (fig. 79) somewhat resembling in structure those in *S. unguolata*, the inner ramus being composed of only two very unequal joints; the 1st long and slender, considerably exceeding in length the outer ramus; the 2nd quite short and armed on the tip with a strong claw and a comparatively short seta accompanied by a small hair. Natatory legs about as in the four preceding species. Last pair of legs (fig. 80) resembling in shape those in *S. minuticornis*, though wanting one of the small marginal spines on the distal joint.

Length of adult female 0.43 mm.

Remarks.—The peculiar armature of the anal segment and of the caudal rami will suffice for distinguishing at once this species from any of the preceding, and it is from this character that the specific name here proposed is derived. In the structure of the 1st pair of legs it differs conspicuously from the type.

Occurrence.—A single female specimen of this form was found in the above-mentioned sample taken in Tanganyika at Mbete.

12. SCHIZOPERA FIMBRIATA, sp. n. (Plate XII. figs. 82–86.)

Specific Characters.—FEMALE. Body (fig. 82) moderately slender and slightly attenuated behind. Rostrum well defined and of the usual narrow lanceolate form. Last caudal segment fully as long as the preceding one, and, as in *S. spinulosa*, armed above on each side of the anal area with an oblique row of small spinules; anal opercle well developed, semilunar, and fringed with a regular row of about 16 similar spinules. Caudal rami (fig. 86) considerably shorter than the anal segment and of oval form; inner edge somewhat curved at the base; spine of outer edge short and thick, curved outwards, and attached somewhat nearer to the end than to the base; dorsal seta likewise issuing behind the middle; upper face of each ramus armed with three transverse rows of extremely fine spinules, the 1st crossing the base, the 2nd extending from the inner edge to the dorsal seta, the 3rd occurring just above the insertion of the apical setae. Anterior antennae comparatively short, but composed of the normal number of joints. First pair of legs (fig. 83) with both rami comparatively short, last joint of outer ramus not attaining the length of the middle one; inner ramus composed of only two joints, the 1st about the length of the outer ramus, the 2nd scarcely more than one-third as long and armed on the tip with a claw-like spine and a slender seta accompanied by a small hair-like bristle. Natatory legs (fig. 84) with unusually short rami, but otherwise of normal structure. Last pair of legs (fig. 85) likewise shorter than usual; distal joint scarcely longer than it is broad, and, as in *S. spinulosa*, only provided with five marginal setae; inner expansion of proximal joint extending about as far as the distal joint.

Length of the specimen examined 0.44 mm.

Remarks.—The most characteristic feature of this species is undoubtedly the structure of the anal opercle, which, as in the species of the genus *Nitocra*, is fringed with a regular row of spinules, and it is indeed from this character that the specific name here proposed is derived. Moreover, the peculiar shape of the outer spine of the caudal rami is rather characteristic and affords another easily observable specific mark.

Occurrence.—A single, apparently not yet fully grown female specimen of this form was found in a sample from Lake Nyasa, taken 13/6/04 in Anchorage Bay, south end of the lake.

13. SCHIZOPERA SCALARIS, sp. n. (Plate XIII. figs. 87-92.)

Specific Characters.—MALE. Body (fig. 87) slender and elongated, with rather coarse integuments and all the segments very sharply marked off from each other, giving it a scalariform appearance. Rostrum well defined at the base, but of a somewhat unusual form, being very broad, lamellar, and terminating in an obtuse point. Segments of the anterior division each with a small nodiform prominence laterally. Last caudal segment shorter and narrower than the preceding one and without any spinules dorsally; anal opercle perfectly smooth. Caudal rami (fig. 92) much produced and very narrow, sublinear in form; inner edge straight and quite smooth; spine of outer edge moderately strong and attached at a short distance from the end; dorsal seta likewise issuing far behind the middle; median apical seta very strong and elongated. Anterior antennæ (fig. 88) of moderate size, and hinged in the usual manner. First pair of legs (fig. 89) with a highly chitinated, obtusely pointed projection issuing from the inner corner of the 2nd basal joint, in addition to the usual spine; outer ramus of quite normal structure; inner ramus distinctly prehensile, 3-articulate, 1st joint long and slender, considerably exceeding in length the outer ramus, the other two joints quite short and somewhat imperfectly separated; last joint armed at the tip with a strong curved claw and a slender seta accompanied by a small hair-like bristle. Natatory legs well developed and of the structure characteristic of the genus; inner ramus of 2nd pair of legs (fig. 90) transformed in the usual manner. Last pair of legs (fig. 91) with the distal joint comparatively small and somewhat fusiform in shape, with only five very unequal marginal setæ; inner expansion of proximal joint short and truncated at the tip, which carries two thickish juxtaposed setæ ciliated in their outer part.

Length of the specimen examined 0.49 mm.

Remarks.—In its external appearance this form looks very different from the other species, and by its pronouncedly scalariform body, the broad rostral plate, and the slender and narrow caudal rami, it much more resembles some species of the genera *Laophonte* and *Cletodes*. The anatomical examination has, however, proved it to be a genuine member of the present genus.

Occurrence.—The above-described male specimen, the only one that has come to my notice, was found in a sample from Tanganyika, taken 24/2/05 at Baraka, north-western shore of the lake.

Family CLETODIDÆ.

This family is chiefly distinguished from the *Laophontidæ*, to which it bears some resemblance, by the non-prehensile 1st pair of legs. The type of the family is the genus *Cletodes* Brady, to which in recent times several other genera have been added, all from the sea.

Genus ILYOPHILUS Lilljeborg.

Generic Characters.—Body more or less cylindric in form, with rather thin and flexible integuments and the segments sharply marked off from each other. Cephalic segment large, and projecting in front to a rounded rostral plate not defined at the base. Urosome attenuated behind, with the genital segment distinctly divided in the middle. Caudal rami more or less produced, not lamellar, with one of the apical setæ very strong, spiniform. Anterior antennæ in female composed of only five joints, thickly clothed with partly spiniform setæ; those in male distinctly hinged. Posterior antennæ rather strong, with the distal joint armed with coarse claw-like spines; outer ramus small, uniarticulate. Mandibular palp likewise uniarticulate. Maxillæ and maxillipeds comparatively short and stout. First pair of legs only slightly differing from the succeeding ones, and not prehensile; inner ramus in this and the two succeeding pairs biarticulate and much smaller than the outer, that of the 4th pair quite rudimentary, uniarticulate; 3rd pair of legs in male slightly transformed. Last pair of legs comparatively small, with the distal joint well defined or confluent with the proximal one; inner expansion of the latter broad, but not projecting. A single ovisac present in female.

Remarks.—This genus was established in the year 1902 by Prof. Lilljeborg, to comprise a small Harpacticoid, *I. flexibilis* Lilljeborg, found by him off the shores of the Baltic in the neighbourhood of Stockholm. I have myself met with the same species near Christiania, in shallow bays of the Fjord, and thus have had an opportunity of examining it more closely. Prof. Lilljeborg refers this genus to the subfamily Nannopodinae of Brady, which, according to that author, comprises the two genera *Nannopus* and *Platychelipus*. The first of these genera is still very imperfectly known, but is apparently referable to the family Cletodidae. The second genus, in my opinion, is very different, and ought to be referred to the family Laophontidae. In any case, the present genus seems to me to be a genuine Cletodid, exhibiting, as it does, all the essential characters of that family.

14. ILYOPHILUS PERPLEXUS, sp. n. (Plate XIII. figs. 93–104.)

Specific Characters.—FEMALE. Body (figs. 93 & 94) rather short and stout, more or less curved, and gradually attenuated from before backwards, with no sharp demarcation between the anterior and posterior divisions. All the segments of the body sharply defined, and having the hind edge somewhat raised but quite smooth. Cephalic segment very large and broad, with a slight dorsal depression about in the middle, and with the lateral parts boldly curved anteriorly. Rostral projection evenly rounded at the tip and densely clothed with fine hairs (see fig. 95). The four succeeding segments comparatively short and obtusely produced laterally. Urosome almost as long as the anterior division;

genital segment very distinctly divided in the middle; last segment fully as long as the preceding one and slightly widening at the end; anal opercle small, but somewhat prominent, and perfectly smooth. Caudal rami about twice as long as they are broad, sub-linear in form and slightly diverging, each carrying on the tip a strong spiniform seta tipped with a slender bristle and accompanied on each side by a very small hair-like bristle; seta of outer edge likewise small, hair-like, and attached about in the middle; dorsal seta issuing somewhat nearer to the end. Anterior antennæ (fig. 95) rather strong and curved, with the 1st joint very thick, though scarcely longer than the 2nd; 3rd joint carrying at the end anteriorly the usual sensory filament, which is rather small; the last two joints, forming together the terminal part, very unequal, the 1st quite short, the 2nd somewhat lamellar and armed with two strong spines and several thin flexible setæ. Posterior antennæ (fig. 96) with five strong claw-like spines on the distal joint, increasing in length distally; outer ramus very small and only provided with three setæ at the tip. Mandibular palp (fig. 97) likewise smaller than in the typical species. Maxillæ (fig. 98) and anterior maxillipeds (fig. 99) of about the same appearance as in that species. Posterior maxillipeds (fig. 100), however, comparatively less powerful. 1st pair of legs (fig. 101) with the inner corner of 2nd basal joint conically produced and tipped with a strong spine; terminal joint of outer ramus armed with three slender spines and a single seta issuing from the inner corner; inner ramus scarcely longer than the 1st joint of the outer. The two succeeding pairs of legs (fig. 102) only differing from the 1st in the want of a spine at the inner corner of the 2nd basal joint, and in the terminal joint of outer ramus being somewhat broader and provided with one or two additional setæ. 4th pair of legs (fig. 103) with one of these setæ shortened and spiniform; inner ramus quite rudimentary, consisting of a single small, nodiform joint tipped with a slender seta. Last pair of legs (fig. 104) rather small, with the distal and proximal joints wholly confluent, forming together a short and broad lamella produced outside to a conical process, to which a slender hair-like bristle is attached; posterior edge of the lamella irregularly indented and fringed with seven thickish, finely ciliated setæ.

Length of adult female 0.49 mm.

Remarks.—The above-described form unquestionably is referable to the genus *Ilyophilus*, as defined by Prof. Lilljeborg, but is quite certainly specifically distinct from the typical species *I. flexibilis*, differing, as it does, in some points very markedly. Thus the caudal rami are much more produced, and the last pair of legs are distinguished by the complete coalescence of the two joints of which these legs are originally composed. It is also rather inferior in size.

Occurrence.—Only a single female specimen of this remarkable form has come to my notice. It was picked up from some muddy deposit contained in a sample from Tanganyika, taken 13/10/04

at Sumbu, western shore of the lake. From the same sample also several of the above described species of the genus *Schizopera* were derived.

III. CYCLOPOIDA.

The Cyclopoida found in the collection are referable to two particular sections of that extensive division, viz., the Gnathostomata and the Pœcilostomata. The first of these sections comprises the typical free-living Cyclopoida, in which the oral parts are normally developed. To the second section, on the other hand, are referred forms which lead a more or less parasitic life, and in which therefore the oral parts have been transformed in accordance therewith, though not to such an extent as in a third section, not represented in the collection, the Siphonostomata.

Sect. Gnathostomata.

Family CYCLOPIDÆ.

Genus CYCLOPS Müller.

By far the great majority of Copepod-species found in the collection belong to this extensive and widely distributed genus. No less than 20 different species have been determined, 16 of which have proved to be new to science.

The distinction of the species of this genus is in some cases determined with no small difficulty. For, whereas some of them are at once recognised, there are other species which are so closely related, that a very careful examination is needed for distinguishing the one from the other. For the discrimination of nearly allied species, much stress has generally been laid on the structure of the rudimentary last pair of legs. The examination of these diminutive appendages is, however, by no means easy, and cannot be effected without a very careful dissection of the specimens. There are several other characters, which are much more easily accessible for examination and consequently of more practical value. Among them may be mentioned the mutual relation in length of the caudal setæ. As this relation has proved to be perfectly constant in all individuals of the same species, and admits of being examined at once, without any dissection of the specimens, it affords one of the practically best characters for the distinction of nearly-related species. Especially is the mutual relation between the innermost and outermost apical seta in many cases very characteristic.

Owing to the great number of species comprised within this genus, it will probably in future be found advisable to effect a subdivision of it into several nearly allied genera. It is well known indeed that Dr. Schmeil, in his excellent account of the fresh-water Cyclopida, has arranged the European species in several groups, and in recent times some attempts have been made

to raise these groups to distinct genera or subgenera. In the present paper I find it, however, appropriate to retain the old generic name *Cyclops* for all the species here recorded, though they are enumerated in a definite succession according to their affinity.

15. *CYCLOPS LEUCKARTI* Claus. (Plate XIV. figs. 105–107.)

Occurrence.—This truly cosmopolitan species was found in several of the samples from all three lakes. In some of the samples from Tanganyika it occurred in great abundance, and may, together with *Diaptomus simplex*, form a chief part of the surface-plankton of that lake. In a sample from Nyasa, taken 13/6/04 in the Anchorage Bay, a smaller variety occurred not unfrequently. For comparison with the two succeeding species, I give on the accompanying plate a figure of a typical female specimen from Victoria Nyanza, together with two detail-figures.

16. *CYCLOPS EMINI* Mrázek. (Plate XIV. figs. 108–112.)

Cyclops emini Mrázek, Die Copepoden Ost-Afrikas, p. 4, pl. ii. figs. 1–3, 5, 6, 8.

Specific Characters.—FEMALE. Body (fig. 108) rather slender, with the anterior division oblong-oval in form and slightly widening anteriorly, front narrowly truncated. Last pedigerous segment small, not produced laterally. Urosome slender and narrow, considerably exceeding half the length of the anterior division; genital segment only very slightly widening in front. Caudal rami (fig. 112) much longer than the anal segment and rather narrow, being somewhat divergent; seta of outer edge attached a little behind the middle; innermost apical seta more than twice as long as the outermost, but considerably shorter than the outer mediate one; dorsal seta unusually long and slender, extending beyond the innermost apical seta. Anterior antennæ very long and slender, almost attaining the length of the whole anterior division, and 17-articulate. Posterior antennæ (fig. 109) likewise unusually slender, with the terminal joint narrow linear in form, and the penultimate joint only provided with four anteriorly-curving setæ. Natatory legs with the rami comparatively long and slender; inner ramus of fourth pair (fig. 110) with the two apical spines very unequal, the inner one rather slender, the outer scarcely more than one-third as long, both distinctly denticulate. Last pair of legs (fig. 111) very small, distal joint narrow oblong in form, and having the lateral spine longer than the apical seta. Ovisacs comparatively small and somewhat divergent, each with a rather limited number of ova.

Length of adult female 0.79 mm.

Remarks.—This form has been described, though somewhat imperfectly, under the above name by Dr. Mrázek. It is closely allied to the European species, *C. oithonoides* G. O. Sars, exhibiting a very similar external appearance, though at once distinguished

by the comparatively shorter innermost caudal seta. In *C. oithonoides* this seta is about the same length as the outer mediate one, whereas in the present species it is scarcely more than two-thirds as long. The extraordinary length of the dorsal seta has also been noted by Dr. Mrázek. He has, however, not been aware of the rather striking difference from most other species in the structure of the posterior antennæ. According to its organisation, this species, like *C. leuckarti*, may be regarded as a true limnetic or planktonic form.

Occurrence.—I have only found this form in one of the samples, viz., that from Bukoba, Victoria Nyanza. It did not occur in any abundance. Dr. Mrázek has recorded it also from the island Djuma in the same lake.

17. *CYCLOPS NEGLECTUS*, nom. nov. (Plate XIV. figs. 113–117.)

Syn.: *Cyclops hyalinus* Richard (not Rehberg).

„ *oithonoides* Mrázek (not G. O. Sars).

Specific Characters.—FEMALE. Body (fig. 113) much shorter and stouter than in the preceding species, with the anterior division regularly oval in form and the front evenly rounded. Last pedigerous segment small, not produced laterally. Urosome about half the length of the anterior division, and having the genital segment slightly widening in front. Caudal rami (fig. 117) very short, scarcely exceeding in length the anal segment, and almost twice as long as they are broad; seta of outer edge attached at about the posterior third of the ramus; apical setæ comparatively short, innermost one not attaining half the length of the outer mediate seta and scarcely twice as long as the outermost; dorsal seta of moderate length. Anterior antennæ not nearly attaining the length of the anterior division of the body, and 17-articulate. Posterior antennæ (fig. 114) of normal appearance, with about nine anteriorly-curving setæ on the penultimate joint. Natatory legs with the rami less slender than in *C. emini*; inner ramus of fourth pair (fig. 115) with the apical spines very unequal in size. Last pair of legs (fig. 116) resembling those in the said species, though having the lateral spine of the distal joint comparatively shorter. Ovisacs not very large, oval in form, and only containing a limited number of ova.

Length of adult female 0.73 mm.

Remarks.—This form is closely allied to the European species *C. hyalinus* Rehberg, and indeed Dr. Richard, and formerly also I myself, identified it with that species. It is, however, on a closer comparison, at once distinguished by the much shorter innermost caudal seta. Whereas in *C. hyalinus* this seta is about the same length as the outer mediate one, it is in the present form scarcely more than half as long. Dr. Mrázek has identified this form with *C. oithonoides* G. O. Sars, to which species it in reality bears only a very remote resemblance.

Occurrence.—Of this species specimens were found in samples from all three lakes; but only in one of them, taken 13/6/04 in the Anchorage Bay, Nyasa, it occurred in any abundance.

Distribution.—Senegal at Rufinesque (*Richard*), Sumatra (*G. O. Sars*); ? Germany (*Richard*).

18. *CYCLOPS TENELLUS*, sp. n. (Plate XIV. figs. 118–127.)

Specific Characters.—FEMALE. Body (fig. 118) rather slender, with very thin and fragile integuments. Anterior division of body regularly oval in form, with the cephalic segment very large and somewhat truncated in front. Last pedigerous segment very small. Urosome slender and narrow, exceeding half the length of the anterior division; genital segment only very slightly dilated in front. Caudal rami (fig. 127) about twice as long as they are broad and scarcely divergent; seta of outer edge attached nearly in the middle, innermost apical seta very small, scarcely longer than the outermost, inner mediate seta very slender and almost twice as long as the outer, dorsal seta likewise rather much produced. Anterior antennæ (fig. 119) slender and elongated, attaining almost the length of the anterior division of the body, though composed of only twelve articulations clothed with slender bristles, some of them of quite an unusual length. Posterior antennæ (fig. 120) likewise rather slender, with a very limited number of setæ (5) on the penultimate joint. Both pairs of maxillipeds (fig. 121) unusually produced. Natatory legs well developed; terminal joint of outer ramus in the two anterior pairs (figs. 122 & 123) provided with five slender spines and five setæ, in 3rd pair (fig. 124) with only four spines; 1st joint of same ramus, except in the 1st pair, without any seta inside; 4th pair (fig. 125) with both rami very slender and devoid of the seta inside the 1st joint; apical spines of inner ramus very unequal in size. Last pair of legs (fig. 126) extremely small, though apparently of normal structure, apical seta the longest.

Length of adult female 0.38 mm.

Remarks.—This is perhaps the smallest of all the species of *Cyclops*, and is also distinguished rather conspicuously from the other known forms both in its external appearance and the structure of the appendages. It therefore appears somewhat difficult to decide to which group of the genus *Cyclops* it should more properly be referred. I place it provisionally here, next to the three preceding species, to which it exhibits a certain similarity as to the general habitus. To judge from its very thin and pelucid integument and the delicate structure of the appendages, it seems to be a true limnetic form.

Occurrence.—I have only found this tiny species in two of the samples from Tanganyika, one taken 24/2/05 at Baraka, north-western shore of the lake, the other 1/3/05 at Kaboge, in the same region of the lake. Most of the specimens were more or less damaged, owing to the extremely fragile structure of their bodies.

19. *CYCLOPS ALBIDUS* (Jurine). (Plate XV. figs. 128–130.)

Occurrence.—Some few specimens of this well-known species, most of them of the male sex, were found in a sample from Lake Nyasa, taken 11/6/04 in the Anchorage Bay. I give on the accompanying plate a figure of a male specimen together with two detail-figures.

Distribution.—Europe, Asia, North and South America, Australia, Hawaii Islands.

20. *CYCLOPS ATTENUATUS*, sp. n. (Plate XVI. figs. 131–138.)

Specific Characters.—FEMALE. Body (fig. 131) comparatively slender and attenuated behind, with the anterior division oval in form and evenly rounded in front. Last pedigerous segment slightly produced on each side. Urosome somewhat exceeding half the length of the anterior division, and gradually tapering behind; genital segment only slightly dilated in front. Caudal rami (fig. 138) rather produced, exceeding in length the last two segments combined, and of narrow linear form, being not at all divergent; seta of outer edge somewhat remote from the end; innermost apical seta very thin and about twice the length of the outermost, which is somewhat spiniform; the two middle setæ long and slender, the inner one exceeding the outer by rather more than one-third of its length and almost attaining half the length of the whole body. Anterior antennæ (fig. 132) comparatively short, not nearly attaining the length of the cephalic segment, and composed of only ten articulations. Posterior antennæ (fig. 133) of normal structure, with six anteriorly-curving setæ on the penultimate joint. Natatory legs (figs. 134–136) short and stout, with both rami bi-articulate, the last two joints being wholly coalesced. Last pair of legs (fig. 137) with the proximal joint not defined, its seta issuing from the side of the segment itself; distal joint very small, narrow conical in form and tipped with a single seta. Ovisacs small, rounded, each as a rule containing only two or three globular ova.

Length of adult female 0.65 mm.

Remarks.—This form is nearly allied to the European species, *C. varicans* G. O. Sars, having, like the latter, both rami of the natatory legs bi-articulate, and the last pair of legs partly confluent with the pertaining segment. It differs, however, in the somewhat more slender form of the body, the more produced caudal rami, and in the anterior antennæ being composed of only 10 articulations, whereas in *C. varicans* they are distinctly 12-articulate.

Occurrence.—Several specimens of this form were picked up from the muddy deposit contained in one of the samples from Tanganyika, taken 13/10/04 at Sumbu, south-western shore of the lake, and two specimens, male and female, were found in another sample, taken 28/9/04 at Mbete, south end of the lake.

21. *CYCLOPS VARICANS* G. O. Sars. (Plate XVI. figs. 139, 140.)

Occurrence.—A single female specimen of this form was found in a sample from Lake Nyasa, taken 13/6/04 in the Anchorage Bay, and another somewhat smaller specimen in a sample from Tanganyika, taken 28/9/04 at Mbete, south end of the lake.

Distribution.—Europe, New Zealand (*G. O. Sars*).

22. *CYCLOPS EXIGUUS*, sp. n. (Plate XVI. figs. 141, 142.)

Specific Characters.—**FEMALE**. Body (fig. 141) rather narrow, with the anterior division oblong-oval in form and obtusely produced in front. Last pedigerous segment with the lateral parts slightly prominent and each tipped with a slender bristle. Urosome slender, considerably exceeding half the length of the anterior division; genital segment only very slightly dilated in front. Caudal rami (fig. 142) not attaining the length of the last two segments combined, of nearly uniform width throughout, and scarcely at all divergent; seta of outer edge attached somewhat behind the middle, innermost apical seta very thin and fully twice as long as the outermost, the two middle setae of moderate length and having the cilia of their proximal part much coarser than those of the distal part, the inner one exceeding the outer by about one-third of its length. Anterior antennae rather short, and composed of only 11 articulations. Legs of a similar structure to those of the two preceding species.

Length of adult female 0.53 mm.

Remarks.—The present form is closely allied to the European species, *C. bicolor* G. O. Sars, but is of smaller size and more narrow form of body. It also differs in the shorter anterior antennae and in the less produced caudal rami.

Occurrence.—Only a single female specimen of this form has come to my notice. It was found in a sample from Tanganyika, taken 28/9/04 at Mbete, south end of the lake.

23. *CYCLOPS CUNNINGTONI*, sp. n. (Plate XVII. figs. 143–150.)

Specific Characters.—**FEMALE**. Body (fig. 143) comparatively short and robust, with the anterior division rather broad and pronouncedly depressed, having its greatest width somewhat behind the middle. Cephalic segment very large, and gradually narrowed in front to an obtusely conical point. Lateral parts of the three succeeding segments somewhat expanded, but with the hind corners rounded off. Last pedigerous segment forming on each side a short obtuse prominence tipped with a slender ciliated seta. Urosome rather thick, about half the length of the anterior division and slightly tapering behind; genital segment somewhat dilated in its anterior part. Caudal rami (fig. 150) not nearly attaining the length of the last two segments combined and slightly widening at the end; seta of outer edge attached somewhat behind the middle; innermost apical seta only slightly longer

than the outermost, which is spiniform; the two middle setæ rather coarse, almost spiniform, and of moderate length; the inner one exceeding the outer by about one-third of its length, dorsal seta not much produced. Anterior antennæ (fig. 144) comparatively short and thick at the base, consisting of 12 articulations densely clothed with slender curved setæ especially on the proximal part. Posterior antennæ (fig. 145) with the seta attached to the hind corner of the basal joint rather short; penultimate joint provided with nine anteriorly-curving setæ, and about the length of the terminal joint. Natatory legs (figs. 146-148) short and stout and, as in the three preceding species, having both rami bi-articulate. Last pair of legs (fig. 149) quite rudimentary, each consisting of only a very small conical joint tipped with a single seta, the basal joint being wholly confluent with the pertaining segment. Ovisacs of moderate size, oblong oval in form, and somewhat divergent, each containing from ten to sixteen ova.

Length of adult female 0.86 mm.

Remarks.—This is a very distinct and easily recognisable form, being especially distinguished from the three preceding species, with which it agrees in the structure of the legs, by the short and robust body, the broad, pronouncedly depressed anterior division, and the conically produced cephalic segment. It is indeed one of the most characteristic endemic forms of Lake Tanganyika, and I have therefore thought it right to associate with it the name of the distinguished conductor of the Expedition.

Occurrence.—I have found this pretty form in four of the samples from Tanganyika. In one of these samples, the same which contained the above-described species, *C. attenuatus*, it occurred rather frequently, more rarely in the three other samples. Of these one was taken 12/12/04 at Karema, eastern shore of the lake, another 1/3/05 at Kaboge, north-western shore, and a third 28/9/04 at Mbete, south end of the lake.

24. *CYCLOPS PACHYCOMUS*, sp. n. (Plate XVII. figs. 151-156.)

Specific Characters.—FEMALE. Body (fig. 151) considerably more slender than in *C. cunningtoni*, with the anterior division less expanded and the cephalic segment obtusely rounded in front. Last pedigerous segment about as in that species. Urosome somewhat exceeding half the length of the anterior division and gradually tapering behind. Caudal rami (fig. 156) somewhat narrower than in *C. cunningtoni*, though scarcely longer, and not at all diverging; seta of outer edge attached about in the middle, innermost apical seta scarcely longer than the outermost, the two middle setæ rather slender and elongated, the inner one almost twice as long as the outer and exceeding half the length of the whole body. Anterior antennæ (fig. 152) very short and robust, and composed of only 11 articulations thickly covered with very coarse, almost spiniform setæ, several of which are distinctly ciliated. Posterior antennæ (fig. 153) likewise shorter and stouter than in the preceding species. Natatory legs of a very similar

structure to that in *C. cunningtoni*, except that the spines on both rami of the 4th pair (fig. 154) are shorter and blunt at the tip. Last pair of legs (fig. 155) exhibiting the same rudimentary structure as in that species.

Length of adult female 0.62 mm.

Remarks.—Though closely allied to the preceding species, this form is at once distinguished by the less expanded anterior division of the body, the different shape of the cephalic segment, the more slender caudal setæ, and finally by the shorter and thicker anterior antennæ, which moreover are only 11-articulate, and have the setæ of the anterior edge and upper face remarkably coarse. The specific name here proposed is derived from this last character.

Occurrence.—Some few female specimens of this form were found in two of the samples from Tanganyika, the one taken 28/9/04 at Mbete, south end of the lake, the other 13/10/04 at Sumbu, south-western shore.

25. *CYCLOPS SEMISERRATUS*, sp. n. (Plate XVIII. figs. 157–169.)

Specific Characters.—**FEMALE**. Body (fig. 157) moderately slender, with the anterior division regularly oval in form, the greatest width occurring about in the middle. Cephalic segment large and obtusely truncated in front. Last pedigerous segment with the lateral parts slightly expanded and clothed with fine hairs. Urosome somewhat exceeding half the length of the anterior division; genital segment comparatively short and distinctly dilated at the base, carrying on each side a slender bristle (see fig. 167). Caudal rami (fig. 169) long and slender, considerably exceeding in length the last three segments combined, and of narrow linear form, slightly widening at the tip; outer edge armed for about half its length with a row of very small denticles, seta of this edge small and attached close to the end somewhat dorsally, innermost apical seta only slightly longer and much thinner than the outermost; middle setæ rather slender with the cilia of uniform appearance throughout, the inner one exceeding the outer by rather more than one-third of its length and abruptly bent outwards at the middle. Anterior antennæ (fig. 158) comparatively slender, considerably exceeding the cephalic segment in length, and composed of 12 articulations. Posterior antennæ (fig. 159) of moderate length, and having the seta of the basal joint well developed. Oral parts (figs. 160–163) and natatory legs (figs. 164–166) built on the same type as in *C. serrulatus* Fischer. Last pair of legs (figs. 167, 168) as in that species, each composed of a single small, somewhat lamelliform joint, trilobate at the end and carrying two slender bristles and at the inner corner a ciliated spine, the latter, however, much smaller than in *C. serrulatus*. Ovisacs regularly oval in form and only very slightly divergent.

Length of adult female 0.86 mm.

Remarks.—This form, like the six succeeding species, belongs to the group of Cyclops for which *C. serrulatus* Fischer is the type, and which has proved to contain several well-defined species formerly generally regarded as only varieties of the said species. The present form is nearly allied to *C. macruroides* Lilljeborg, differing, however, in some particulars, for instance in the armature of the caudal rami and the mutual relation in length of the apical seta, so it may be more properly regarded as specifically distinct.

Occurrence.—This form occurred very abundantly in one of the samples from Tanganyika, taken 19/9/04 at Niamkolo Island, south end of the lake. It was not found in any of the other samples.

26. CYCLOPS LÆVIMARGO, sp. n. (Plate XIX. figs. 170–175.)

Specific Characters.—FEMALE. Body (fig. 170) comparatively more robust than in the preceding species, with the anterior division slightly dilated in front. Last pedigerous segment and urosome about as in that species. Caudal rami (fig. 175) of a similar narrow linear form, but with the outer edge perfectly smooth, without any trace of the regular row of denticles found in that species; innermost apical seta scarcely longer than the outermost, the two middle setae comparatively shorter than in *C. semiseratus* and quite uniformly ciliated, the inner one only exceeding the outer by one-fourth of its length and slightly bent outwards at the middle. Anterior antennae (fig. 171) much shorter than in that species, scarcely attaining the length of the cephalic segment, though composed of the same number of articulations. Posterior antennae (fig. 172) likewise shorter and stouter. Fourth pair of legs (fig. 173) with the spines on the outer ramus comparatively short and blunt at the tip. Last pair of legs (fig. 174) with the spine of the inner corner small, though perhaps a little longer than in the preceding species. Ovisacs comparatively small and scarcely divergent.

Length of adult female 0.85 mm.

Remarks.—The present form differs conspicuously from the preceding one by the much shorter anterior antennae and by the absolute absence on the outer edge of the caudal rami of the regular series of denticles generally found in the species belonging to this group. It is from this last character that the specific name here proposed is derived.

Occurrence.—This form also was only found in one of the samples from Tanganyika, but in this rather abundantly. The sample was taken 12/12/05 at Karema, eastern shore of the lake.

27. CYCLOPS ANGUSTUS, sp. n. (Plate XIX. figs. 176–180.)

Specific Characters.—FEMALE. Body (fig. 176) very slender and narrow, with the anterior division oblong in form and obtusely truncated in front. Last pedigerous segment with the lateral parts only slightly expanded. Urosome attaining about two-

thirds of the length of the anterior division; genital segment conspicuously dilated at the base. Caudal rami (fig. 180) exceedingly slender and elongated, almost attaining the length of the remaining part of the urosome; outer edge perfectly smooth, seta of this edge attached at only a short distance from the end and accompanied at the base in front by a transverse row of four small denticles; innermost apical seta about the length of the outermost; the two middle setæ rather slender and uniformly ciliated, the inner one exceeding the outer by about one-third of its length. Anterior antennæ 12-articulate and of moderate length, being about as long as the cephalic segment, their outer joints (fig. 177) conspicuously longer than in *C. levimargo*. Natatory legs of normal structure. Last pair of legs (fig. 179) extremely small, with the spine of the inner corner very short. Ovisacs about as in the two preceding species.

Length of adult female 0.82 mm.

Remarks.—This form at the first sight looks very like the European species, *C. macrurus* G. O. Sars. On a closer comparison, however, it is found to differ in the comparatively more slender anterior antennæ, and more particularly in the structure of the caudal rami. In the European species the seta of the outer edge is much more remote from the end, and in front of it four denticles occur, which do not form a transverse row, as in the present species, but are arranged along the edge. Moreover, the innermost apical seta is considerably longer than the outermost, and the spine of the inner corner in the last pair of legs more fully developed.

Occurrence.—Some few specimens of this form were found in a sample from Tanganyika, taken 18/11/04 at Kala, eastern shore of the lake. One female and two male specimens of apparently the same species occurred in a sample from Lake Nyasa, taken 13/6/04 in the Anchorage Bay.

28. *CYCLOPS RARISPINUS*, sp. n. (Plate XIX. figs. 181, 182.)

Specific Characters.—FEMALE. Body (fig. 181) comparatively short and stout, with the anterior division ovoid in form and narrowly truncated in front. Last pedigerous segment with the lateral parts somewhat produced and clothed with fine hairs. Urosome slightly exceeding half the length of the anterior division, and having the genital segment rather much dilated at the base. Caudal rami (fig. 182) much shorter than in the three preceding species and also less narrow, scarcely widening at the end; outer edge armed with a short row of about eight small denticles not extending to the middle of the ramus, inner edge finely ciliated in its proximal half; innermost apical seta nearly twice as long as the outermost; the two middle setæ rather slender and uniformly ciliated, the inner one exceeding the outer by rather more than one-third of its length. Anterior antennæ moderately slender and distinctly 12-articulate. Legs apparently of normal structure. Ovisacs comparatively small and scarcely divergent.

Length of adult female 0·80 mm.

Remarks.—In the form and armature of the caudal rami this form somewhat resembles a species recorded by Dr. Mrázek from small ponds at Bukoba, Victoria Nyanza, and named *C. stuhlmanni*. To judge from the figure given by that author, this form is, however, much more slender in shape, and the anterior antennae are composed of only 10 articulations, whereas in the present form they are distinctly 12-articulate, as in all the other species belonging to this group.

Occurrence.—Only a single female specimen of this form has come to my notice. It was found in a sample from Tanganyika, taken 18/11/04 at Kala, eastern shore of the lake.

29. *CYCLOPS AGILOIDES*, sp. n. (Plate XX. figs. 183–188.)

Specific Characters.—FEMALE. Body (fig. 183) rather slender, with the anterior division gradually widening anteriorly, front evenly rounded. Last pedigerous segment short, but rather broad. Urosome slender, considerably exceeding half the length of the anterior division; genital segment somewhat dilated at the base. Caudal rami (fig. 188) of moderate length, about as long as the last two segments combined, and slightly divergent; outer edge armed with a row of very small denticles, which in the proximal part of the ramus are somewhat withdrawn from the edge and become so minute that they easily may escape attention; innermost apical seta nearly twice as long as the outermost; the two middle setae of moderate length and uniformly ciliated, the inner one exceeding the outer by rather more than one-third of its length. Anterior antennae rather slender, considerably exceeding in length the cephalic segment, and 12-articulate, the last three joints (fig. 184) with a distinct smooth longitudinal keel. Posterior antennae (fig. 185) of quite normal structure. Fourth pair of legs (fig. 186) with the spines of both rami finely denticulate, the apical ones of the inner ramus slightly unequal in size. Last pair of legs (fig. 187) with the spine of the inner corner well developed and coarsely denticulate.

Length of adult female 0·90 mm.

Remarks.—This form is closely allied to the European species, *C. agilis* Koch (= *C. varius* Lilljeborg), but differs in some particulars, especially as regards the form and armature of the caudal rami, so as more properly to be regarded as specifically distinct.

Occurrence.—A single female specimen (that described above) of this form was found in the above-mentioned sample from Victoria Nyanza, and two other specimens of apparently the same species were derived from Tanganyika, the one from a sample taken 19/9/04 at Niamkolo, south end of the lake, the other in a sample taken 13/10/04 at Sumbu, south-western shore.

30. *CYCLOPS EUACANTHUS*, sp. n. (Plate XX. figs. 189–192.)

Specific Characters.—FEMALE. Body (fig. 189) comparatively

slender, with the anterior division oblong-oval in form and narrowly truncated in front. Last pedigerous segment with the lateral parts slightly produced and finely hairy. Urosome exceeding half the length of the anterior division, and having the genital segment somewhat dilated in front. Caudal rami (fig. 192) about half the length of the remaining part of urosome and somewhat divergent, outer edge armed with a comb-like row of rather strong denticles extending almost to the base of the ramus; innermost apical seta very thin and quite naked, being more than twice as long as the outermost, the latter pronouncedly spiniform and pointing almost straight outwards, its anterior edge fringed with fine spinules, posterior edge smooth; middle setæ slender and uniformly ciliated, the inner one exceeding the outer by rather more than one-third of its length. Anterior antennæ scarcely as long as the cephalic segment, and 12-articulate; last and penultimate joints (see fig. 190) each provided with a finely denticulated longitudinal keel. Fourth pair of legs (fig. 191) with the spines attached to the terminal joint of both rami unusually large, lanceolate in form, with a dense fringe of delicate spinules on each side. Last pair of legs not examined. Ovisacs of moderate size and oval in form, slightly divergent.

Length of adult female 0.79 mm.

Remarks.—This form is especially distinguished by the very conspicuous comb-like series of denticles on the outer edge of the caudal rami, the strong spiniform outermost apical seta, and finally by the unusual development of the spines attached to the terminal joint of both rami in the fourth pair of legs. It is from this latter character that the specific name here proposed is derived.

Occurrence.—Two female specimens of this form had been mounted by Dr. Cunningham, together with some other Entomostraca, on a slide, which was kindly sent to me for examination. According to the label, they were collected from the Lofu river, Tanganyika.

31. *CYCLOPS CILIATUS*, sp. n. (Plate XX. figs. 193, 194.)

Specific Characters.—*FEMALE.* Body (fig. 193) resembling, as to the general form, that of the preceding species, though perhaps somewhat less slender. Caudal rami (fig. 194) comparatively narrower, with the denticles of the outer edge smaller, inner edge clothed throughout its whole length with delicate, somewhat distant cilia; innermost apical seta distinctly ciliated and only slightly exceeding in length the outermost; the latter moderately strong, with the outer edge minutely denticulated, the inner clothed with long cilia; middle setæ rather slender, with the cilia of the proximal part coarser and more distant than those of the distal part, the inner one almost twice as long as the outer. Anterior antennæ more slender and elongated than in the preceding species, with no keel on the outer joints. Fourth pair of legs with the spines of quite normal appearance. Last pair of legs (not figured) with the spine of the inner corner very small.

Length of adult female 0.86 mm.

Remarks.—The present form is distinguished from the preceding one, to which it bears some resemblance in its external appearance, by the comparatively more elongated anterior antennæ, the quite normal structure of the spines attached to the rami of the fourth pair of legs, and finally by the somewhat different form and armature of the caudal rami. The distinctly ciliated inner edge of these rami is another character by which the present species is distinguished, and which has given rise to the specific name here proposed.

Occurrence.—Two female specimens of this form (of which one was dissected) were found in a sample from Tanganyika, taken 28/9/04 at Mbete, south end of the lake.

32. *CYCLOPS OLIGARTHURUS*, sp. n. (Plate XXI. figs. 195–202.)

Specific Characters.—**FEMALE.** Body (fig. 195) rather strongly built and somewhat depressed, with the anterior division ovoid in form, frontal part conically produced. Last pedigerous segment short but rather broad, and having the lateral parts densely clothed with stiff hairs (see fig. 201). Urosome somewhat robust, with the genital segment considerably dilated at the base. Caudal rami (fig. 202) rather produced, about equalling in length the last three segments combined, and slightly diverging; dorsal face armed, in front of the very small seta of the outer edge, with an obliquely transverse row of very small denticles; all the apical setæ pronouncedly spiniform and without true cilia, the innermost and outermost ones of about equal size; inner mediate seta nearly three times as long as the outer, both clothed in their distal part with very minute denticles; dorsal seta quite short. Anterior antennæ (fig. 196) unusually short and compact, scarcely exceeding half the length of the cephalic segment, and composed of only six articulations densely clothed with coarse setæ, some of which exhibit a comb-like series of thin spinules on the one edge, one of these setæ issuing from the end of the first joint being particularly strong and extending along the outer part of the antenna to its very tip. Posterior antennæ (fig. 197) likewise unusually short and stout, with the outer two joints imperfectly separated and the seta of the basal joint very long. Natatory legs (figs. 198–200) resembling in structure those in *C. fimbriatus* Fischer, the middle joint of the inner ramus being very large and acutely produced at the outer corner, with the edge in front of the latter coarsely spinulose. Last pair of legs (fig. 201) each consisting of a single somewhat irregular joint armed with three strong spines, the outermost of which is much the largest and distinctly denticulate, pointing outwards, so as to project on each side of the pertaining segment (see fig. 195). Ovisacs comparatively small, and each containing only a very limited number of ova.

Length of adult female 0.69 mm.

Remarks.—The nearest ally of this form is unquestionably the European species, *C. fimbriatus* Fischer, with which it agrees in

the more general characters. Yet it is quite certainly specifically distinct from that species, exhibiting as it does a number of well-marked differences, of which may be named the spiniform character of the caudal setæ, the coarse spines with which the last pair of legs are armed, and the unusually small number of joints in the anterior antennæ. No other true *Cyclops* has such a small number of joints in these antennæ, and it is only in the genus *Halicyclops* that a similar composition of the anterior antennæ is met with. The specific name here proposed refers to this last character.

Occurrence.—Some few specimens of this remarkable form were found in a sample from Tanganyika, taken 28/9/04 at Mbete, south end of the lake. Two specimens (male and female) occurred in another sample, taken 12/12/04 at Karema, eastern shore of the lake.

33. *CYCLOPS COMPACTUS*, sp. n. (Plate XXI. figs. 203, 204.)

Specific Characters.—FEMALE. Body (fig. 203) of a very compact structure, with the anterior division broadly oval in form and pronouncedly depressed. Cephalic segment gradually contracted anteriorly, with the frontal part narrowly rounded. Lateral parts of the three succeeding segments somewhat expanded. Last pedigerous segment short, but rather broad. Urosome considerably exceeding half the length of the anterior division and only very slightly tapering behind; last segment comparatively short, and clothed laterally with fine spinules. Caudal rami somewhat produced, equalling in length the last two segments combined; inner edge straight and perfectly smooth, outer edge armed somewhat behind the middle with two or three small denticles, seta of this edge very small and attached near the end somewhat dorsally; tip obliquely truncated, with the innermost seta much smaller than the outermost; middle setæ well-developed and clothed for some part of their length with small spinules, the inner one much elongated, considerably exceeding half the length of the body and fully twice as long as the outer. Anterior antennæ comparatively short and not much dilated at the base, being composed of 10 articulations. Last pair of legs (see fig. 204) each composed of a short joint extending laterally and carrying three unusually large recurved setæ, the longest of which extends as far as the second caudal segment, all the setæ clothed with scattered spinules.

Length of adult female 0.75 mm.

Remarks.—This form is closely allied to the European species, *C. phaleratus* Koch, but is easily distinguished by the much more produced caudal rami and by the great development of the setæ attached to the last pair of legs.

Occurrence.—A single female specimen of this form occurred in the same mounted slide which contained the two specimens of the above-described species, *C. euacanthus*.

34. *CYCLOPS DUBIUS*, sp. n. (Plate XXI. figs. 205–207.)

Specific Characters.—FEMALE. Body (fig. 205) rather slender, with the anterior division oblong-oval in form and obtusely rounded in front. Last pedigerous segment (see fig. 206) with the lateral parts rounded off and clothed with unusually long and delicate hairs. Urosome considerably exceeding half the length of the anterior division and somewhat tapering behind; genital segment only slightly widened in front. Caudal rami (fig. 207) long and slender, sublinear in form and slightly divergent, considerably exceeding in length the last two segments combined, outer edge perfectly smooth with a small seta near the end; innermost apical seta small, being much shorter than the outermost, which is spiniform; middle setæ of moderate length and uniformly ciliated, the inner one about twice as long as the outer; dorsal seta not much produced. Anterior antennæ rather short, not nearly attaining the length of the cephalic segment and composed of 12 articulations. Last pair of legs (see fig. 206) each consisting of a single somewhat lamellar joint extended laterally, and provided with three comparatively short spiniform setæ.

Length of adult female 0.62 mm.

Remarks.—The exact relation of this form to the other known species is as yet somewhat doubtful, as the solitary specimen examined has not been dissected. Yet, in spite of the perfectly smooth outer edge of the caudal rami, the short anterior antennæ, and the laterally extended last pair of legs, it may probably belong to the group for which *C. serrulatus* is the type. In any case it may be regarded as a rather abnormal form.

Occurrence.—The above-described specimen was found in a sample from Nyasa, taken 13/6/04 in the Anchorage Bay, south end of the lake.

Sect. *Pæcilostomata*.Fam. *ERGASILIDÆ*.

This family comprises a peculiar group of pæcilostomatous Cyclopoida, which in some respects forms as it were a transition to the true parasites, Caligoida and Lernæoida. The adult females, which in some cases appear rather much deformed, are found firmly attached, by the aid of their clawed posterior antennæ, to the gills of several species of freshwater fishes. The copulation of the sexes in all probability takes place before the fixation of the female, in the last free stage of the latter. We know of two distinct genera of this family, viz. *Ergasilus* Nordman and *Thersites* Pagenstecher. To these a third genus is here added.

Genus *ERGASILOIDES*, n. g.

Generic Characters.—Body of female (in last free stage) cyclopoid in shape, subdepressed in front, and attenuated behind; in

male of more slender form. Head distinctly defined from metasome and very large, more or less scutiform and without any rostrum. Segments of metasome rapidly diminishing in size, the fifth or last very small, almost obsolete. Urosome short, and consisting in female of only two, in male of three segments; genital segment in both sexes large and tumid, that of male having the postero-lateral corners produced and tipped with a small spine. Caudal rami short, each carrying on the inner corner a strong seta, which in some cases is bifid, outer corner provided with three much smaller setæ, one of which is extended outwards. Anterior antennæ of a similar structure in the two sexes, comparatively short and stout, 5- or 6-articulate, and densely clothed with delicate setæ. Posterior antennæ transformed into strong prehensile organs, larger in female than in male. Oral area produced in the form of a short tube issuing from the ventral face of the head behind, and provided inside with two pairs of incurved appendages (mandibles and maxillæ), outside with a small lamella (maxilliped), which in male is transformed into a well-developed prehensile organ terminating in a clawed hand. Natatory legs with the rami more or less incurved and clothed at the end with slender ciliated setæ; those of the fourth pair much smaller than the others, with the number of joints in the outer ramus reduced. Last pair of legs extremely small and rudimentary, knob-like, with a single small seta on the tip. Adult stage of female still unknown.

Remarks.—This new genus is chiefly distinguished from *Ergasilus*, to which it bears a close resemblance, by the reduced number of segments in the urosome of both sexes. In the corresponding stage of *Ergasilus* the urosome is composed in the female of four well-defined segments and in the male of five such segments. Moreover, the very rudimentary condition of the last pair of legs and of the segment to which they are attached, is rather characteristic. Three different species of this genus have been determined.

35. *ERGASILOIDES MEGACHEIR*, sp. n. (Plate XXII. figs. 208–222.)

Specific Characters.—FEMALE in last free stage. Body (figs. 208 & 209) comparatively short and stout, pronouncedly depressed, and, viewed dorsally, subpyriform in outline. Head very large and expanded, almost quadrangular in form; dorsal face with a well-marked transverse fold at about the posterior third of its length, and moreover exhibiting two small but sharply defined areas, the one of circular form and occurring in front of the middle, the other cordiform and placed near the posterior edge; frontal edge of the head transversely truncated, postero-lateral corners only slightly prominent and rounded. The four anterior segments of metasome with the lateral parts slightly produced backwards but obtusely rounded at the end. Last segment almost wholly concealed. Urosome scarcely exceeding in length one-third of

the metasome; genital segment much dilated, rounded oval in form. Caudal rami about the length of the last segment, with the seta of the inner corner simple and pointing straight behind. Anterior antennæ (fig. 210) consisting of six well-defined articulations gradually diminishing in size. Posterior antennæ (fig. 211) very largely developed; propodus twice as long as the basal joint and oblong in form, being scarcely narrowed distally, anterior edge with a thin hyaline border not fully extending to the base; dactylus about half the length of the propodus and somewhat twisted, its terminal claw comparatively short, with a recurved denticle inside. Oral parts (see figs. 212–215) exhibiting the structure characteristic of the genus. Natatory legs (figs. 216–218) with both rami distinctly 3-articulate, except the outer ramus of 4th pair (fig. 218), which is only biarticulate. Last pair of legs (fig. 219) extremely small.

MALE (fig. 220) smaller than female and of considerably more slender form. Head much less expanded and rounded in front, its dorsal face without any distinct sculpturing. Segments of metasome evenly rounded laterally. Urosome more slender than in female and about half the length of the metasome. Anterior antennæ only 5-articulate. Posterior antennæ (fig. 221) much smaller than in female and of simpler structure. Maxillipeds (fig. 222) well developed, with the dactylus very slender.

Length of female in last free stage 0.62 mm., of male 0.55 mm.

Remarks.—This form is especially distinguished by the great size and peculiar structure of the prehensile posterior antennæ in the female, which character has given rise to the specific name here proposed.

Occurrence.—Three female specimens (in the last free stage) and some few immature ones were found in a sample from Tanganyika, taken 13/10/04 at Sumbu, south-western shore of the lake.

36. *ERGASILOIDES MACRODACTYLUS*, sp. n. (Plate XXIII. figs. 223, 224.)

Specific Characters.—FEMALE (in last free stage). Body (fig. 223) resembling in its general shape that of the preceding species, though perhaps a little more slender. Head very large and expanded, subquadrate in outline, with the dorsal face sculptured in a similar manner to that in the preceding species, frontal margin transversely truncated, postero-lateral corners distinctly projecting, subangular. Urosome with the genital segment less tumid, inner caudal seta simple. Anterior antennæ composed of only five articulations. Posterior antennæ (fig. 224) very long and slender; propodus fully twice as long as the basal joint and attenuated distally, with no hyaline border; dactylus remarkably elongated, almost attaining the length of the propodus, with the terminal claw slender and perfectly smooth. Legs of apparently the same structure as in the preceding species.

Length of female (in last free stage) 0.50 mm.

Remarks.—This form is nearly allied to the preceding one, but of smaller size, and moreover easily distinguished by the rather different shape of the prehensile posterior antennæ, the dactylus of which is unusually long and slender. The specific name here proposed refers to this last character.

Occurrence.—A solitary female specimen of this form was found in the same sample in which the preceding species occurred.

37. *ERGASILOIDES BREVIMANUS*, sp. n. (Plate XXIII. figs. 225–231.)

Specific Characters.—FEMALE (in last free stage). Body (fig. 225) somewhat fusiform in shape, the head bulging considerably in its posterior part and gradually tapering anteriorly, front obtusely rounded. Dorsal face quite smooth without any trace of the peculiar sculpture found in the two preceding species. Segments of metasome evenly rounded laterally. Urosome (fig. 230) of a similar structure to that in the two preceding species. Caudal rami, however, distinguished by the seta of the inner corner being bifid, or divided near the base into two somewhat unequal prongs, the outer one being the longer. Anterior antennæ composed of only five articulations. Posterior antennæ (fig. 226) much shorter and stouter than in the two preceding species, with the propodus scarcely longer than the basal joint and quite simple; dactylus strong and somewhat dilated at the base, its terminal claw evenly curved and perfectly smooth. Natatory legs (figs. 227–229) with the outer two joints of the rami confluent.

MALE (fig. 231) resembling in its external appearance that of *E. megacheir*, but at once recognisable by the bifid inner caudal setæ.

Length of female 0.62 mm., of male 0.47 mm.

Remarks.—This form may be easily distinguished from the two preceding species by the different shape of the head in the female, the peculiar bifid inner caudal setæ, and more particularly by the much shorter and stouter posterior antennæ in the female, which latter character has given rise to the specific name here proposed.

Occurrence.—Two or three females and one male specimen of this form were found in a sample from Tanganyika, taken 28/9/04 at Mbete, south end of the lake. A single female specimen occurred in a sample from Nyasa, taken 13/6/04 in Anchorage Bay.

Genus *ERGASILUS* Nordman.

38. *ERGASILUS* sp.

Occurrence.—A single female specimen (in the last free stage) of a genuine *Ergasilus*, with distinctly 4-articulate urosome and

the last pair of legs developed in exactly the same manner as in the European species, is present in a mounted slide containing some other Entomostraca, which, according to the label, are from Lake Nyasa. The specimen has not yet been examined in detail, and is therefore only mentioned here. Dr. Mrázek also records a species of this genus, probably the same as that here mentioned, from Victoria Nyanza.

GENERAL REMARKS.

The working out of the Copepoda of the Tanganyika Expedition has involved no small difficulty and trouble, both as regards the selection of the specimens from the samples, and the examination and determination of the species, some of which, especially of the genus *Cyclops*, are so closely related to each other and to European species, that a very minute and careful examination has been needed to make out their true relationship. Yet, I think that the labour thereon bestowed may not have been in vain. For the final results of my examination have turned out to be on the whole very satisfactory, and have indeed far surpassed the expectation at first entertained. I hope therefore that the present Report will furnish a not unimportant contribution both to the exact definition of species, and to the general characterisation of the fauna in the three great Central African lakes.

The number of Copepod-species examined and mentioned in the present Report amounts to no less than 38 in all, belonging to six different genera. Of these species the far greater number, viz. 30, have proved to be new to science, and of the genera two have previously been known only from salt or brackish water. Finally, one new genus, *Ergasiloides*, has been established, to comprise three species allied to *Ergasilus* Nordman.

The annexed table is intended to show the distribution in the three lakes of the species here recorded, and, at the same time, the number of species found in each of them. It will at once appear from this table that Lake Tanganyika is by far the richest in Copepoda, no less than 29 species having been recorded from there, whereas a rather limited number of species is found in the two other lakes, viz., in Nyasa 11, in Victoria Nyanza only 7 species. This agrees pretty well with the results which other authors have obtained, in regard to the richness and specialisation of forms in that lake, as compared with the fauna of the other African lakes.

In striking contrast hereto stands, however, the apparently total absence in Tanganyika of Cladocera. Although I have with the greatest care sought for forms of this group in the numerous samples from this lake, I have only succeeded in finding in one of them a solitary specimen of a *Moina*, and this specimen in all probability has only quite accidentally been carried into the lake from some neighbouring stream.

Table of Distribution.

Names of Species.	Tanganyika.	Nyasa.	Victoria Nyanza.	Europe and other parts of the world.
<i>Diaptomus galeboides</i> G. O. S.	+	
" <i>mixtus</i> G. O. S.	+		
" <i>stuhlmanni</i> Mrázek	+	
" <i>simplex</i> G. O. S.	+			
" <i>cunningtoni</i> G. O. S.	+		
<i>Schizopera</i> <i>inopinata</i> G. O. S.	+			
" <i>validior</i> G. O. S.	+			
" <i>consimilis</i> G. O. S.	+	...	+	
" <i>ungulata</i> G. O. S.	+			
" <i>minuticornis</i> G. O. S.	+			
" <i>spinulosa</i> G. O. S.	+			
" <i>fimbriata</i> G. O. S.	+		
" <i>scalaris</i> G. O. S.	+			
<i>Ilyophilus perplexus</i> G. O. S.	+			
<i>Cyclops leuckarti</i> Claus	+	+	+	+
" <i>emini</i> Mrázek	+	
" <i>neglectus</i> G. O. S.	+	+	+	+
" <i>tenellus</i> G. O. S.	+			
" <i>albidus</i> Jurine	+		+
" <i>attenuatus</i> G. O. S.	+			
" <i>varicans</i> G. O. S.	+	+	...	+
" <i>exiguus</i> G. O. S.	+			
" <i>cunningtoni</i> G. O. S.	+			
" <i>pachycomus</i> G. O. S.	+			
" <i>semiserratus</i> G. O. S.	+			
" <i>lævimargo</i> G. O. S.	+			
" <i>angustus</i> G. O. S.	+	+		
" <i>rarispinus</i> G. O. S.	+			
" <i>agiloides</i> G. O. S.	+	...	+	
" <i>euacanthus</i> G. O. S.	+			
" <i>ciliatus</i> G. O. S.	+			
" <i>oligarthrus</i> G. O. S.	+			
" <i>compactus</i> G. O. S.	+			
" <i>dubius</i> G. O. S.	+		
<i>Ergasiloides megacheir</i> G. O. S.	+			
" <i>macrodactylus</i> G. O. S.	+			
" <i>brevimanus</i> G. O. S.	+	+		
<i>Ergasilus</i> sp.	+		

Dr. Cunningham also has noticed this peculiar feature of Lake Tanganyika. In the other two lakes, on the other hand, a number of well-marked species of that group occur, both true limnetic and bottom-forms.

Of the six genera of Copepoda here recorded, the genus *Cyclops* is represented by far the greatest number of species, viz., in all 20; next to it comes the genus *Schizopera* with 8 species, the genus *Diaptomus* with 5 species, the genus *Ergasiloides* with 3 species, and finally the genera *Ilyophilus* and *Ergasilus*, each with a single species.

As to the distribution of the species, it ought to be noted that the three lakes have each their particular forms of *Diaptomi* not found out of the respective lakes, one species occurring in

Tanganyika, two in Nyasa, and two others in Victoria Nyanza. Of the genus *Schizopera* a single species (*S. fimbriata*) seems to be peculiar to Lake Nyasa; all the other seven species are found in Tanganyika, and of these only one (*S. consimilis*) is stated to occur also in one of the other lakes (Victoria Nyanza). The remarkable genus *Ilyophilus*, as above stated, is only represented by a single species from Tanganyika. Of the 20 species of the genus *Cyclops*, 17 have been stated to occur in Tanganyika. Two of these (*C. leuckarti* and *C. neglectus*) are common to all three lakes; three species (*C. varicans*, *C. angustus*, and *C. agiloides*) occur occasionally also in the other lakes, the first two in Nyasa, the last in Victoria Nyanza. The remaining 12 species, on the other hand, seem to be endemic forms of Lake Tanganyika. Of the three species which have not yet been found in Tanganyika, one (*C. emini*) seems to be an endemic form of Victoria Nyanza; the second (*C. albidus*) is a widely distributed, almost cosmopolitan species, like *C. leuckarti*; and the third (*C. dubius*) is as yet only known from a solitary specimen found in Nyasa. The three species of the genus *Ergasiloides* occur all in Tanganyika, and only one of them (*C. brevimanus*) is occasionally also found in Nyasa. In the latter lake, finally, a still undetermined species of the genus *Ergasilus* occurs.

Particular attention ought to be paid to the two remarkable genera, *Schizopera* and *Ilyophilus*. Both these genera must evidently be regarded as of marine origin, and the question thus arises, how we shall explain the occurrence of species of these genera in the purely freshwater lakes of Central Africa. The most obvious inference appears to be the belief, that these species are true "relict" forms, that is to say, the remains of an ancient marine fauna prevailing here at a time when the lakes formed part of the Ocean; and indeed a supposition in favour of such a conclusion was advanced some time ago by Mr. J. E. S. Moore, who is of opinion that Lake Tanganyika might be the modified remains of part of an ancient Jurassic Sea, and that its fauna accordingly in some instances exhibits distinct traces of more primitive (marine) characters. Recent investigation of this lake tends, however, to disprove the supposition set forth by Mr. Moore about the fauna of Lake Tanganyika, and to show that it is on the contrary a highly specialised one, and does not exhibit any true relation to marine forms. I am myself also of opinion that the theory of Mr. Moore about his so-called "halolimnic" (relict) forms can scarcely be supported. But, how are we to explain the presence in Lake Tanganyika of species of the two above-mentioned genera? I think that we need not regard these as true "relict" forms, although their marine origin seems to be indisputable. We have in this case recourse to another explanation, which may prove to be fully sufficient, namely, the *accidental transport by the aid of migratory aquatic birds*. The importance of such a transport for the distribution of small freshwater animals has long been recognised. It is indeed easily

understood, that not rarely it may happen that parcels of mud adhering to the feet of such birds and containing germs of small organisms, may be transported from one basin to another for rather a long distance. Several of these germs, for instance the resting ova of Rotatoria, Planaria, Bryozoa, and small Crustacea, may be kept for years in a dried condition, without losing their developing power, and of course will easily develop when brought under favourable conditions. Even in the case of animals, which do not produce such resting ova, a successful transport in this way may be effected. A very interesting discovery has recently been made by Prof. Birge and Mr. Juday at the Laboratory of the Wisconsin Geol. and Nat. Hist. Survey, in the case of a common species of the genus *Cyclops* (*C. bicuspidatus* Claus)*. It has been stated by these authors that this form, at certain periods of the season, is subjected to a peculiar encysting process, small, still immature specimens enveloping themselves with a rather firm cocoon of muddy particles held together by some glutinous matter. It is very easy to believe that such cocoons may be kept in a dry condition for a long time without any damage to the enclosed young *Cyclops*, and that consequently an accidental transport of them by migratory birds may be as successful as that of true resting ova. It also appears very probable that a similar encysting process may be found to be present in other species of this genus. In any case, the discovery of Prof. Birge and Mr. Juday cannot fail to throw an unexpected light upon certain difficult questions regarding the distribution of some species of the genus *Cyclops*, and perhaps also of forms not belonging to that genus.

The above remarks on the accidental transport of animals by the aid of migratory birds, chiefly concerns true freshwater forms. However, as the said birds not only visit freshwater lakes, but also the coasts of the sea, it is evident that a transport of mud from the sea-shores to freshwater lakes may occasionally take place. In most cases, certainly, the germs contained in such mud will not develop when brought into purely fresh water, yet it is not impossible that the development of some few forms may in reality be effected under such circumstances. This may be assumed to be the case with marine animals that have accustomed themselves to live in more or less brackish water, and this is precisely the case with the type species of both the two above-mentioned genera. One of them, *Hyophilus flexibilis*, has even been stated by Prof. Lilljeborg to occur occasionally also in purely fresh water, having been found, besides in the Baltic, also in the neighbouring Lake Mælaren, and this fact clearly proves that such brackish water animals in reality possess the power of accustoming themselves to living in fresh water.

It has been stated above, that no less than eight different

* "A summer resting-stage in the development of *Cyclops bicuspidatus* Cls."

species of the genus *Schizopera* have been found in the Central African lakes, seven of them occurring in Lake Tanganyika. On a closer examination, it has been proved that none of these species is identical with the type-species, *S. longicauda*, exhibiting as they do some well-marked differences of apparently specific value. Of course, it would be quite unreasonable to assume that all these species have been transported to the lake in the above-mentioned manner. In my opinion these species have developed independently in the lake from a single ancestral form (perhaps *S. longicauda*), which in some remote time has found its way to the lake in the above-mentioned manner, and which, owing to the altered condition of life and isolation, has gradually changed its characters and undergone a divergent development into several varieties. These varieties in their turn have at last attained the character of distinct species.

In a similar manner the African species, *Ilyophilus perplexus*, may have been originally derived from the type species, *I. flexibilis*, though the alteration of characters, which has taken place, is great enough to distinguish it as a well-marked species. The occasional occurrence of two species of the genus *Schizopera* in the two other African lakes, in all probability is due to an accidental transport from the neighbouring Lake Tanganyika, and the same may also be the case with some other Copepod-species stated to occur both in that lake and in one or other of the two remaining lakes. It may be observed here, that Lake Tanganyika in its general physical characters differs from the other two lakes. It is extremely long and narrow, in some places exhibiting very considerable depths, and we have historical evidence to prove that its water was formerly somewhat brackish in character. Nyasa, it is true, while not so long, is also deep and relatively narrow, but Victoria Nyanza is very broad and quite shallow. The above-mentioned and other physical and perhaps also biological peculiarities of Lake Tanganyika seem to have favoured, during a long period of isolation, a divergent development of certain species, and this development in some cases has proceeded to such an extent as to produce even new generic types, all of which, however, have conserved the stamp of their phylogenetic relation to other forms occurring in the same lake or otherwise. Such highly specialised forms, representing particular genera, have been recorded among the Brachyura by Dr. Cunningham, and among the Macrura by Dr. Calman. Also among the Copepoda a new generic type has been found, viz., *Ergasiloides*, with three well-marked species. The phylogenetic relation of this genus to the genus *Ergasilus* is very obvious, the generic difference chiefly consisting in a somewhat retrograde transformation of the posterior part of the body.

A development, in comparatively recent times, of new species and even genera in isolated basins, is by no means a unique feature exclusively peculiar to Lake Tanganyika. We know of similar cases also from other parts of the world. Thus, it is well

known that Lake Baikal in Siberia distinguishes itself in a quite remarkable manner from the other Asiatic lakes by its astonishing richness in various species of Gammarid Amphipoda. It is impossible to explain this peculiarity of Lake Baikal without assuming that a divergent development from one or a few ancestral forms has taken place here. In the Caspian Sea, too, we meet with a quite similar case, not only in the Amphipoda, but also in other groups of Crustacea, viz. Mysidæ, Cumacea, Polyphemidæ, as is shown by the present author in his several papers on the Carcinological Fauna of that interesting basin.

EXPLANATION OF THE PLATES.

PLATE VI.

Diaptomus galeboides G. O. Sars.

- Fig. 1. Adult, ovigerous female, dorsal view.
 2. Same, viewed from left side.
 3. Urosome together with part of metasome, more highly magnified, and viewed from the dorsal face.
 4. Right lateral corner of last segment of metasome, still more highly magnified.
 5. Leg of last pair.
 6. Adult male, dorsal view.
 7. Terminal section of right anterior antenna.
 8. Last pair of legs.

PLATE VII.

Diaptomus mixtus G. O. Sars.

- Fig. 9. Adult female, dorsal view.
 10. Same, viewed from left side.
 11. Posterior part of metasome and genital segment, dorsal view.
 12. Leg of last pair.
 13. Adult male, dorsal view.
 14. Middle and terminal sections of right anterior antenna.
 15. End of terminal part of same antenna, more highly magnified.
 16. Last pair of legs.
 17. Projection of the 2nd basal joint of right leg, more highly magnified.

PLATE VIII.

Diaptomus stuhlmanni Mrázek.

- Fig. 18. Adult ovigerous female, dorsal view.
 19. Same, viewed from left side.
 20. Left lateral part of last segment of metasome.
 21. Leg of last pair.
 22. Terminal part of right anterior antenna in male.
 23. Last pair of legs of same.
 24. Outer ramus of left leg, viewed from the anterior face, more highly magnified.

Diaptomus simplex G. O. Sars.

- Fig. 25. Adult ovigerous female, dorsal view.
 26. Same, viewed from left side.
 27. Urosome together with posterior part of metasome, dorsal view.
 28. Right lateral part of last segment of metasome, somewhat more magnified.
 29. Leg of last pair.
 30. Outer three joints of right anterior antenna of male.
 31. Last pair of legs of same.
 32. Outer ramus of left leg, viewed from the anterior face, and more highly magnified.

PLATE IX.

Diaptomus cunningtoni G. O. Sars.

- Fig. 33. Adult female, dorsal view.
34. Another female, with attached spermatophore, viewed from left side.
35. Urosome together with posterior part of metasome, dorsal view.
36. Left lateral part of last segment of metasome, with adjoining part of genital segment, dorsal view.
37. Same part viewed from the exterior face.
38. Last pair of legs.
39. Adult male, dorsal view.
40. Terminal part of right anterior antenna of same.
41. Last pair of legs.
42. Outer ramus of left leg, viewed from the anterior face, and more highly magnified.

PLATE X.

Schizopera inopinata G. O. Sars.

- Fig. 43. Adult ovigerous female, dorsal view.
44. Same, viewed from left side.
45. Rostrum together with right anterior antenna, dorsal view.
46. Right posterior antenna.
47. Outer ramus of same, highly magnified.
48. Mandible with palp.
49. Posterior maxilliped.
50. Leg of 1st pair.
51. Leg of 2nd pair.
52. Leg of 3rd pair.
53. Leg of 4th pair.
54. Last pair of legs.
55. Extremity of urosome, with the caudal rami, dorsal view.
56. Anterior antenna of male.
57. Inner ramus of a leg of 2nd pair of same.
58. Leg of last pair of same.

PLATE XI.

Schizopera validior G. O. Sars.

- Fig. 59. Adult ovigerous female, dorsal view.
60. Anterior antenna.
61. Leg of 1st pair.
62. Leg of last pair.
63. Right caudal ramus.

Schizopera consimilis G. O. Sars.

- Fig. 64. Adult ovigerous female, dorsal view.
65. Leg of 1st pair.
66. Leg of last pair.
67. Right caudal ramus.

Schizopera unguolata G. O. Sars.

- Fig. 68. Adult female, dorsal view.
69. Leg of 1st pair.
70. Leg of last pair.
71. Left caudal ramus.

PLATE XII.

Schizopera minuticornis G. O. Sars.

- Fig. 72. Adult female, dorsal view.
73. Rostrum together with right anterior antenna, dorsal view.
74. Leg of 1st pair.
75. Leg of 2nd pair.
76. Leg of last pair.
77. Left caudal ramus, with adjoining part of urosome, dorsal view.

Schizopera spinulosa G. O. Sars.

Fig. 78. Adult female, dorsal view.

79. Leg of 1st pair.

80. Leg of last pair.

81. Left caudal ramus, with adjoining part of urosome, dorsal view.

Schizopera fimbriata G. O. Sars.

Fig. 82. Female (not fully grown), dorsal view.

83. Leg of 1st pair.

84. Leg of 4th pair.

85. Leg of last pair.

86. Left caudal ramus, with adjoining part of urosome, dorsal view.

PLATE XIII.

Schizopera scalaris G. O. Sars.

Fig. 87. Adult male, dorsal view.

88. Anterior antenna.

89. Leg of 1st pair.

90. Leg of 2nd pair.

91. Leg of last pair.

92. Extremity of urosome, with right caudal ramus, dorsal view.

Ilyophilus perplexus G. O. Sars.

Fig. 93. Adult female, dorsal view.

94. Same, viewed from left side.

95. Rostrum, together with left anterior antenna, dorsal view

96. Right posterior antenna.

97. Mandible with palp.

98. Maxilla.

99. Anterior maxilliped.

100. Posterior maxilliped.

101. Leg of 1st pair.

102. Leg of 3rd pair.

103. Leg of 4th pair.

104. Leg of last pair.

PLATE XIV.

Cyclops leuckarti Claus.

Fig. 105. Adult female, dorsal view.

106. Terminal joint of inner ramus of a leg of 4th pair.

107. Leg of last pair.

Cyclops emini Mrázek.

Fig. 108. Adult ovigerous female, dorsal view.

109. Posterior antenna.

110. Inner ramus of a leg of 4th pair.

111. Leg of last pair.

112. Extremity of urosome, with the caudal rami, dorsal view.

Cyclops neglectus G. O. Sars.

Fig. 113. Adult ovigerous female, dorsal view.

114. Posterior antenna.

115. Inner ramus of a leg of 4th pair.

116. Leg of last pair.

117. Extremity of urosome, with the caudal rami, dorsal view.

PLATE XV.

Cyclops tenellus G. O. Sars.

- Fig. 118. Adult female, dorsal view.
119. Anterior antenna.
120. Posterior antenna.
121. The two maxillipeds on left side.
122. Leg of 1st pair.
123. Leg of 2nd pair.
124. Outer ramus of a leg of 3rd pair.
125. Leg of 4th pair.
126. Leg of last pair.
127. Extremity of urosome with the caudal rami, dorsal view.

Cyclops albidus (Jurine).

- Fig. 128. Adult male, dorsal view.
129. Inner ramus of a leg of 4th pair.
130. Right half of the last pedigerous segment and of the genital segment viewed from the ventral face, exhibiting the corresponding leg of last pair and genital lamella, as also an enclosed spermatophore.

PLATE XVI.

Cyclops attenuatus G. O. Sars.

- Fig. 131. Adult ovigerous female, dorsal view.
132. Anterior antenna.
133. Posterior antenna.
134. Leg of 1st pair.
135. Leg of 3rd pair.
136. Leg of 4th pair.
137. Lateral part of last pedigerous segment, with the corresponding rudimentary leg.
138. Extremity of urosome, with the caudal rami, dorsal view.

Cyclops varicans G. O. Sars.

- Fig. 139. Adult female, dorsal view.
140. Extremity of urosome, with the caudal rami.

Cyclops exiguus G. O. Sars.

- Fig. 141. Adult female, dorsal view.
142. Extremity of urosome, with the caudal rami.

PLATE XVII.

Cyclops cunningtoni G. O. Sars.

- Fig. 143. Adult ovigerous female, dorsal view.
144. Anterior antenna.
145. Posterior antenna.
146. Leg of 1st pair.
147. Leg of 3rd pair.
148. Leg of 4th pair.
149. Lateral part of last pedigerous segment, with the corresponding rudimentary leg.
150. Left caudal ramus, with adjoining part of urosome, dorsal view.

Cyclops pachycomus G. O. Sars.

- Fig. 151. Adult female, dorsal view.
152. Anterior antenna.
153. Posterior antenna.
154. Leg of 4th pair.
155. Lateral part of last pedigerous segment, with the corresponding rudimentary leg.
156. Extremity of urosome, with the caudal rami, dorsal view.

PLATE XVIII.

Cyclops semiserratus G. O. Sars.

- Fig. 157. Adult ovigerous female, dorsal view.
158. Anterior antenna.
159. Posterior antenna.
160. Mandible with rudimentary palp.
161. Maxilla.
162. Anterior maxilliped.
163. Posterior maxilliped.
164. Leg of 1st pair.
165. Leg of 3rd pair.
166. Leg of 4th pair.
167. Lateral part of last pedigerous segment, with adjoining part of genital segment, exhibiting the corresponding leg and seta, ventral view.
168. Leg of last pair isolated and more highly magnified.
169. Extremity of urosome, with the caudal rami, dorsal view.

PLATE XIX.

Cyclops laevimargo G. O. Sars.

- Fig. 170. Adult ovigerous female, dorsal view.
171. Anterior antenna.
172. Posterior antenna.
173. Leg of 4th pair.
174. Leg of last pair.
175. Right caudal ramus, with adjoining part of urosome, dorsal view.

Cyclops angustus G. O. Sars.

- Fig. 176. Adult ovigerous female, dorsal view.
177. Outer part of an anterior antenna.
178. Posterior antenna.
179. Leg of last pair.
180. Right caudal ramus, with adjoining part of urosome, dorsal view.

Cyclops rarispinus G. O. Sars.

- Fig. 181. Adult ovigerous female, dorsal view.
182. Left caudal ramus, with adjoining part of urosome.

PLATE XX.

Cyclops agiloides G. O. Sars.

- Fig. 183. Adult female, dorsal view.
184. Outer part of an anterior antenna.
185. Posterior antenna.
186. Leg of 4th pair.
187. Leg of last pair.
188. Left caudal ramus, with adjoining part of urosome, dorsal view.

Cyclops euacanthus G. O. Sars.

- Fig. 189. Adult ovigerous female, dorsal view.
190. Extremity of an anterior antenna.
191. Leg of 4th pair.
192. Right caudal ramus, with adjoining part of last segment, dorsal view.

Cyclops ciliatus G. O. Sars.

- Fig. 193. Adult female, dorsal view.
194. Left caudal ramus, with adjoining part of urosome, dorsal view.

PLATE XXI.

Cyclops oligarthrus G. O. Sars.

- Fig. 195. Adult ovigerous female, dorsal view.
196. Anterior antenna.
197. Posterior antenna.
198. Leg of 1st pair.
199. Leg of 3rd pair.
200. Inner ramus of a leg of 4th pair.
201. Lateral part of last pedigerous segment, with the corresponding leg.
202. Right caudal ramus, with adjoining part of anal segment, dorsal view.

Cyclops compactus G. O. Sars.

- Fig. 203. Adult female, dorsal view.
204. Lateral parts of the last two pedigerous segments and of the genital segment, exhibiting the corresponding leg of last pair, and the short seta, dorsal view.

Cyclops dubius G. O. Sars.

- Fig. 205. Adult female, dorsal view.
206. Posterior part of metasome and adjoining part of genital segment, viewed from the dorsal face, and exhibiting the peculiar ciliation of the last pedigerous segment, and the projecting legs of last pair.
207. Left caudal ramus, with adjoining part of urosome, dorsal view.

PLATE XXII.

Ergasiloides megacheir G. O. Sars.

- Fig. 208. Female in last free stage, viewed from dorsal face.
209. Same, viewed from left side.
210. Anterior antenna.
211. Posterior prehensile antenna.
212. Oral area, viewed from the ventral face, and exhibiting the oral parts *in situ*.
213. Mandible highly magnified.
214. Maxilla.
215. Rudimentary maxilliped.
216. Leg of 1st pair.
217. Leg of 3rd pair.
218. Leg of 4th pair.
219. Rudimentary leg of last pair, together with part of the likewise rudimentary corresponding segment.
220. Adult male, dorsal view.
221. Posterior antenna of same.
222. Maxilliped of same.

PLATE XXIII.

Ergasiloides macrodactylus G. O. Sars.

- Fig. 223. Female in last free stage, dorsal view.
224. Posterior prehensile antenna.

Ergasiloides brevimanus G. O. Sars.

- Fig. 225. Female in last free stage, dorsal view.
226. Posterior prehensile antenna.
227. Leg of 1st pair.
228. Leg of 3rd pair.
229. Leg of 4th pair.
230. Urosome, with the caudal rami, dorsal view.
231. Male, viewed from the dorsal face.

3. A further Note on the Gonadial Grooves of a Medusa, *Aurelia aurita*. By T. GOODEY, B.Sc., University Scholar, Zoological Laboratory, University of Birmingham.*

[Received November 19, 1908.]

(Plate XXIV.†)

In a short paper read before this Society in February last ‡ the occurrence of these grooves was noted and their structure and relations figured and described. The present paper is the outcome of observations which were suggested in the earlier communication and which prove that the grooves actually function as gonoducts. For the purpose, however, of making this paper complete in itself, it has been thought desirable to give a brief résumé of what the former paper dealt with.

It was pointed out that the grooves are four narrow channels, best seen in a subumbrella aspect of the medusa, lying in the interradial axes. They have about the same diameter as the origins of the ordinary gastrovascular canals, and are confined to the ventral walls or floors of the main passages from the central gastric cavity to the gastric pouches, and to the floors of the gastric pouches themselves. They terminate in slightly funnel-shaped expansions at about the centre of each pouch. The boundaries of each groove are formed by two parallel ridges of epithelium which are raised up so as to form a channel between them. It was suggested that, functionally, the grooves serve as channels along which the sex-cells pass on their way to the exterior after having been shed into the gastric pouches at the time of spawning; that they were, in short, incipient gonoducts cut off from the general archenteric cavity or coelenteron.

It seemed desirable to ascertain whether these views were correct by the examination of specimens taken at the period of sexual maturity.

In order to undertake this investigation I spent several weeks in the laboratory of the Marine Biological Station at Plymouth during the month of August, and there collected the necessary material. The specimens were all taken from the open sea and were of the type with very thick mesoglea; those worked on in the University laboratory for the first paper were estuarine specimens and were comparatively thin and discoidal. A large number of medusae, about two hundred in all, were examined with the view of finding sex-cells in the gonadial grooves. Of these only a few, about twelve, possessed grooves in which any obvious contents could be detected. Apparently the reason why comparatively few specimens exhibited grooves with contents, was that

* Communicated by Prof. T. W. BRIDGE, Sc.D., F.R.S., F.Z.S.

† For explanation of the Plate see p. 81.

‡ T. Goodey, P. Z. S. 1908, p. 55.



out of the large number taken only one here and there was at the exact stage when the sex-cells were being extruded; and, further, it appears that the whole of any particular gonad-loop is not ripe at one and the same time, so that only a portion of it may be shed at a time and so perhaps be found in the gonadial groove.

After taking these facts into consideration, it is gratifying to have been able to find some specimens in which the grooves showed unmistakable indications of the presence of sex-cells.

In one or two cases the small masses of material were withdrawn from the grooves by means of a fine pipette and then examined under the microscope. By this means both eggs and masses of spermatozoa were recognised. However, it was not possible to figure these structures accurately under these conditions; and although it was proof that the grooves actually serve as gonoducts, yet it was deemed necessary to obtain figures of the sex-cells in the groove. For this purpose, the remainder of the specimens which showed grooves with contents were dissected and the necessary portions were removed entire. These latter were stained in bulk in borax-carmines for forty-eight hours, dehydrated, and embedded in paraffin-wax. Sections were cut at right angles to the interradial axes along which the grooves lie.

In the preparation of the material for sectionizing, there was a large amount of contraction owing to the great thickness of the mesogloal tissue, and for this reason the lining epithelium in many places became broken up and displaced from its original position. In spite of this, however, the grooves have retained their position and proportions fairly well, and it has been possible to obtain figures of the sex-cells *in situ*.

The first figure (Pl. XXIV. fig. 1) shows a gonadial groove the lining epithelium of which (e) has been fragmented somewhat.

A mass of nucleated tissue is shown lying within the limits of the groove. On the examination of this with high power objectives (fig. 2) it was seen to consist of spermatozoa. Along with the latter there are other large cells which are in various stages of disintegration and are apparently the nurse or nutrient cells (Aders*). The spermatozoa in the middle of the figure can be easily made out, each having a deeply stained nuclear head. In the case of a few spermatozoa, the clear, almost globular middle-piece can be distinguished. Flagella are also very numerous in the section. From the densely aggregated nature of the two masses of male cells at the top and bottom of the figure, and also from their relations with the nutrient cells, it would seem as though spermatogenesis, or at least some of the final stages of the process, may take place within the limits of the groove.

Fig. 3 shows a mass of eggs lying in a groove. Unfortunately, the piece of material from which this section was cut turned

* Zeits. f. wiss. Zool. lxxiv. 1903, p. 95.

out to be very difficult to manipulate in the preparation for sectionizing. There was a very great amount of contraction of the mesogloeal tissue, so that the sections are considerably distorted. However, the figure shows the limits of the groove fairly well with its contained mass of eggs.

The above account affords pretty conclusive proof, I think, of the suggestion that these gonadial grooves function as gonoducts, and that it is only within their limits that the sex-cells pass on their way to the exterior. Also out of all the specimens examined, only comparatively few, as mentioned before, showed anything in the space between the gastric pouch and the central gastric cavity, and in all of these the substance lay in the grooves themselves.

Thus *Aurelia* may be looked upon as possessing coelomic or archenteric derivatives of the nature of primitive gonoducts, standing alone in this respect among the Cœlenterata so far as we know at present, for the origin of the genital ducts of *Ctenoplana korotneffii* is not yet known.

It is of interest to note that other observations along different lines point to the grooves being connected in some way with the gonads. From an examination of a series of specimens of different stages in development, including ephyre and small but complete *Aureliae* of about one inch in diameter, the gradual differentiation of the gastro-vascular system can be traced. In those specimens which show the completely developed gastro-vascular canals, there are slight indications of gonadial grooves in the floors of the almost fully developed gastric pouches. The latter are formed by outgrowths of the central or general gastric cavity along the interradii and by inpushings of this same gastric cavity along the perradii. By the last mentioned process the main passages of connection between the central gastric cavity and the gastric pouches are established. While this process is going on, the gonadial grooves appear as two parallel ridges in the ventral wall of each main passage and gastric pouch. From this it will be seen that the gonadial grooves are of later appearance than the ordinary radial canals. Their complete differentiation is coincident with the final stage in the growth of the gastric pouches, and incidentally they approach completion just prior to the appearance of the gonads.

From this we may safely infer that the gonadial grooves are not concerned with a nutrient function, but rather that they are formed in readiness to discharge their function in connection with the gonads.

Through the kindness of the officials at the British Museum, I was able to examine a number of Acraspedote medusæ in January last. As a result of this I am able to record the presence of the gonadial grooves in another species of the genus *Aurelia*, viz. *Aurelia cerulea*, and in three varieties of *Aurelia aurita*, viz., *A. aurita* var. *japonica*; *A. aurita* var. *cruciata*; and *A. aurita* var. *colpota*.

Pilema octopus, *Pelagia phosphora*, and three specimens of *Cassiopea* were also carefully examined, but no trace of gonadal grooves could be found in any of them.

In conclusion I desire to tender my warmest thanks to Lord Avebury for his kindness in nominating me to the use of a table at the Plymouth laboratory during the month of August, and also to the laboratory officials for the excellent facilities which were afforded me for the collection and examination of specimens during my stay there.

EXPLANATION OF PLATE XXIV.

Gonadal grooves of *Aurelia aurita*.

All the figures are camera lucida drawings. Fig. 2 is with Leitz $\frac{1}{12}$ oil-immersion objective and No. 4 eyepiece.

Fig. 1 ($\times 40$). Section passing through groove, at a point just within the gastric pouch. Thick buttressing mesogloea on either side of the groove. Mass of male cells lying within the groove.

Fig. 2 ($\times 1050$). Portion of section in fig. 1 showing spermatozoa and nutrient cells in the groove.

Fig. 3 ($\times 46$). Section passing through main passage to a gastric pouch, showing gonadal groove in the floor in an almost median position bounded on either side by endodermal epithelial folds. Between the latter is a mass of eggs.

REFERENCE LETTERS.

b.w., body-wall or mesogloea; *d.n.c.*, disintegrating nutrient cells; *e.*, epithelium lining gonadal groove and main passage; *g.g.*, gonadal groove; *g.p.*, gastric pouch; *n.c.*, nutrient cells; *o.*, eggs; *s.p.*, spermatozoa.

4. The Tuberculin Test in Monkeys: with Notes on the Temperature of Mammals. By ARTHUR ERWIN BROWN, D.Sc., C.M.Z.S., Secretary of the Zoological Society of Philadelphia.

[Received November 25, 1908.]

(Text-figures 1-4.)

For many years previous to the introduction of a rigorous quarantine system for incoming monkeys, and of exact measures for the detection of tuberculosis in the Zoological Gardens at Philadelphia, it is believed that at any given time from one-fifth to one-fourth of the monkeys in the collection were tuberculous. Indeed, there have been at least two periods when, under what appeared to be an infection of especial virulence, the death-rate exceeded this average.

A more or less similar experience has been that of the older Zoological Gardens in Europe and America.

In March 1905, upon the opening of the Laboratory of Pathology in the Gardens at Philadelphia, a series of observations was begun by Dr C. Y. White, at that time the Society's pathologist,

and myself, having in view the possible control of this disease. It was known that many of the monkeys coming to the Gardens from the hands of dealers were already infected, and that even in advanced stages they are often of healthy appearance and seldom give reliable external indications of the disease.

The old stock of monkeys had been undergoing a period of acute infection, and without exception they were removed from the Monkey House and for the most part used for experimental purposes, the building itself being thoroughly cleaned and disinfected with formaldehyde vapour. Since then every monkey reaching the Gardens has been placed in a quarantine room, and only those that successfully passed the test of sub-cutaneous injection of tuberculin have been sent to the Monkey House for exhibition. The use of tuberculin has thus been solely for a diagnostic purpose.

Many difficulties were encountered in the early stages of the work, mainly due to the irregularities of temperature in monkeys, and to our initial ignorance of what should be regarded as normal in healthy animals, as well as of the kinds of reaction to be expected in tuberculous cases.

These obstacles were for the most part overcome through careful study of the conditions shown on autopsy in a large number of animals, in connection with the corresponding temperature charts, and it is now felt that the method and the results have reached a large measure of certainty.

The individual variations in temperature are marked, and it is frequently necessary to take a record (rectal in all cases) daily for several weeks before it settles down to approximate regularity, which in our experience is about 101° or 102° Fahr. in the mid-afternoon. This is slightly higher than the 38° Cent. (100.4° F.) assumed as a normal by Simpson and Galbraith*, but it is probable that the difference may be accounted for by the fact noted by us and also shown by those authors, that excitement and muscular effort definitely raises temperature in these animals†. The monkeys used in their observations were handled for a much longer period than ours, and they were able to select those that became relatively indifferent to the usage and restraint involved.

Although we have accepted the above standard as normal, cases have occurred where monkeys have shown temperatures never below 104° at the daily maximum, and are still living and to all appearance in good health.

An important fact was early determined by a sequence of

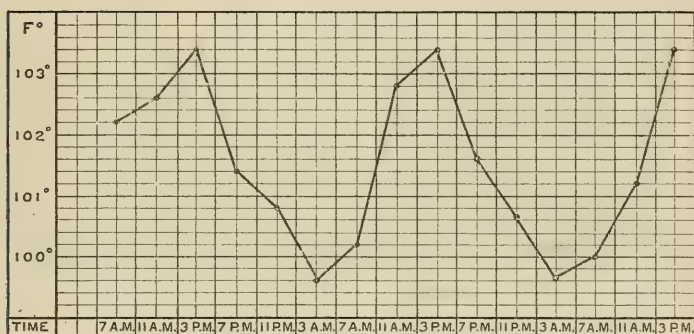
* Trans. Royal Soc. of Edinburgh, xlv. pt. 1, p. 98 (1906).

† An interesting instance is afforded by a lot of five monkeys subjected to the test a few weeks ago. Temperatures were taken daily for two weeks before injection and all ran with unusual regularity. On September 25th, near the end of the period, each chart showed a sharp elevation of from 1.4° to 1.2° F. It was found upon inquiry that the attendant who usually took the temperatures was absent on that day, and the duty fell to another man who had experience in the work but was less gentle in handling the animals, and who, moreover, was quite unknown to this particular lot.

records taken at intervals of four hours during several days, in the existence of a marked daily rhythm or range in the case of every species of monkey examined, the high point being reached toward 3 P.M., about which time a steady fall sets in amounting to three or four degrees by 3 A.M.; from then it rises again to the afternoon maximum. This daily range is shown in Chart A (text-fig. 1), and is in substantial agreement with the results reached by Simpson and Galbraith. It should be mentioned that few charts are as symmetrical as the one selected.

Text-fig. 1.

Chart A.



Cercopithecus pygerythrus ♂ adult.

Temperature chart showing normal daily curve.

In the beginning temperatures were taken for only twenty-four hours after injection, but it was found that reactions are sometimes delayed until the second day, and an essential gain was made in extending the observation period to forty-eight hours.

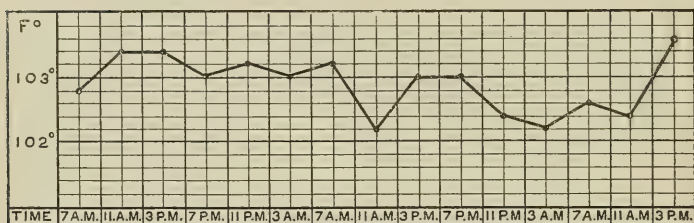
The course of procedure now followed in the tests is that when the daily temperature of the individual monkey has settled down to a somewhat regular course, an injection is made under the loose skin of the lumbar region of from $\frac{3}{4}$ to 2 milligrams of Koch's original tuberculin. This dose is only exceeded in case of exceptionally large animals, such as anubis or chacma baboons, which have received as much as 3 mgs. Injection is made in the forenoon, in order that a rise of temperature concurrent with the upward tendency culminating about 3 P.M. may be noted. Temperatures are then taken at intervals of four hours for two full days. The hours we have selected as best indicating on the chart the daily course, are 7, 11, and 3.

With healthy monkeys we have observed no change in the degree or course of the daily rhythm, following injection, nor ill results of any kind.

In tuberculous subjects the usual result is a general rise of temperature within the first twelve-hour period, though in a few cases the rise has not appeared until the next day, or in many cases a complete destruction of the daily curve ensues, with or without a general rise. This last condition clearly represents the balance reached in the struggle between two opposing tendencies, the upward one due to tuberculin reaction and the downward one which is the normal nightly course, and in meaning is equivalent to a definite rise. Chart B (text-fig. 2) is of this character. In this case, a young rhesus monkey, the temperature before injection ranged from 102.6° to 104.4° .

Text-fig. 2.

Chart B.



Macacus rhesus ♂ juv.

Temperature chart showing tuberculous reaction destroying daily curve,
with no general rise.

It may be noted that in every case showing reaction of either type, autopsy has shown tuberculous lesions*.

The charts most difficult of interpretation, however, in the study of which quite a number of healthy monkeys were sacrificed, are those not infrequent ones in which there is no definite rise in temperature, and no complete destruction of the night drop, but only more or less of a failure to properly complete it. These cases are now held over for retesting after an interval of six or eight weeks, and occasionally the second test gives a positive reaction. It has not infrequently happened that monkeys have been retested as many as three times before a final conclusion was reached. Such charts call for nice discrimination, and, even with the most expert, in them must always lie a possibility of error.

In a few very advanced stages of general tuberculosis there was no reaction rise, and the daily curve was completed, so that a serious certainty of error would arise were it not for the fact that

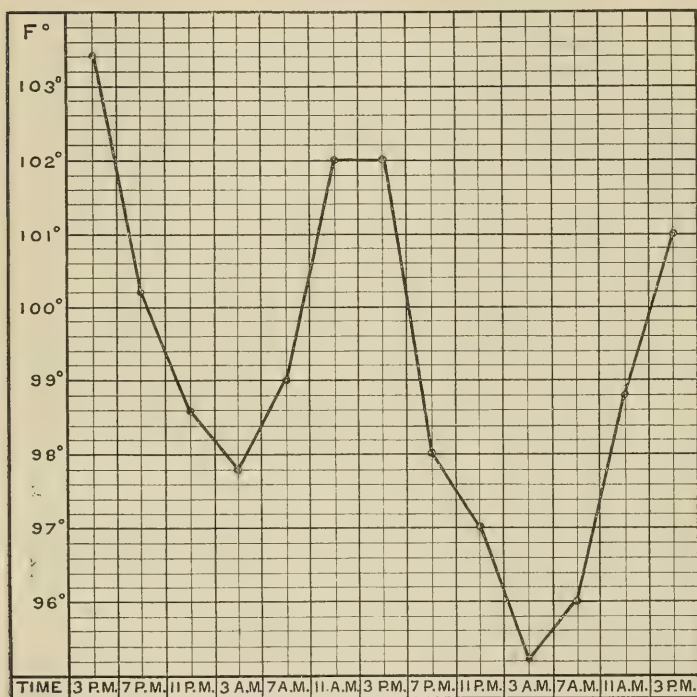
* I am not prepared at this time to suggest an explanation of the difference between our results and those announced by the Royal Commission on Tuberculosis (Second Interim Report, p. 44, London, 1907). If anything has been certain in our experience, it is that in not a single case of definite reaction has autopsy failed to show tuberculosis.

in every such case that we have observed, the whole temperature after injection dropped conspicuously and death speedily followed.

Chart C (text-fig. 3) represents such a case.

Text-fig. 3.

Chart C.



Cercopithecus sabæus ♀ adult.

Temperature chart showing marked post-injection fall in advanced tuberculosis.

These advanced subjects, the only ones in which positive reactions have not been given in presence of tuberculosis, do not impair the practical value of the test, for they are quickly eliminated by death.

In one respect, mainly of pathological interest, much remains to be determined, in the proportion between the degree of reaction and the extent of the tuberculous lesions. So far, we have found an apparent lack of any such constant relation except as noted in very advanced cases, in which, under the large doses of tuberculin used, temperature has made a marked drop.

The necessity for an inflexible practice in the interpretation of

charts cannot be too strongly stated. It has been followed relentlessly throughout our work, and every doubtful case was in the end decided against the monkey. In every case when an animal was condemned, it was etherized and brought to the post-mortem table.

A thoroughly complete system of prevention would perhaps require the retesting of each monkey in the exhibition series at least once a year, but this is no small undertaking in an extensive collection, and we have restricted the practice to those concerning which suspicion arises based on ill-health or other indications. These are immediately removed to the Laboratory and reinjected. If the reaction is bad, the monkeys occupying the same cage are at once taken to the Laboratory and put through the same course. The infected cage as well as the adjoining ones are then thoroughly disinfected.

Quite recently I have made a study of the history of every monkey and lemur that has been tested since March 1905, in the light of the records now in the Laboratory, consisting of two hundred and sixty-seven post-injection temperature charts, and complete post-mortem records of nearly one hundred cases.

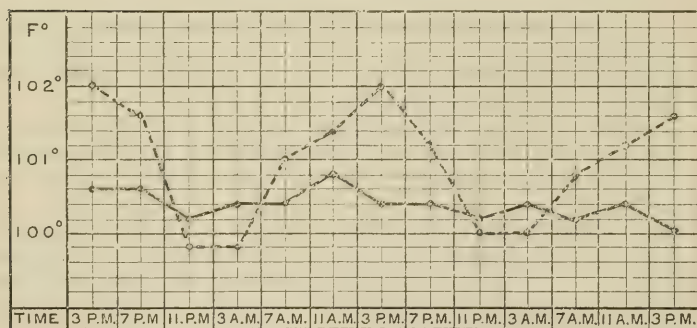
Up to November 1908, the test has been applied to one hundred and sixty-three newly arrived monkeys belonging to *Presbytis*, *Cercopithecus*, *Cercocebus*, *Macacus*, *Cynopithecus*, *Papio*, *Ateles*, *Cebus*, *Chrysothrix*, *Callithrix*, and including a few of the genus *Lemur*. Of these, one hundred and four passed the test and were sent to the Monkey House. Of those not passed, twenty-five were promptly condemned on their reactions and showed tuberculosis on autopsy. The remainder either died from other causes while in quarantine, or were etherized to learn the meaning of dubious charts, during the early and experimental stages of the work.

Of the one hundred and four originally passed, ten have developed tuberculosis during the three and a half years that have elapsed. Three of these died in the exhibition cages, giving no sign of ill-health. The others were detected and returned to the Laboratory, where they were either etherized or secluded. Seven of these cases are traceable with reasonable certainty to two infections from monkeys which were passed early in the tests on twenty-four hour records, whose charts would be considered doubtful in the light of later experience. The three remaining ones were also passed early in the tests, two of them on rather uncertain charts, that of the third being of good quality though somewhat irregular according to our present standards. This monkey, a male *Cercopithecus ruber*, tested in November 1906, died six weeks later from nephritis and fatty degeneration of the liver, and showed early miliary tuberculosis of the intestinal submucosa. With this exception, no monkey passed since February 1906 has as yet shown signs of tuberculosis, and more than a year has elapsed since the last one exhibiting it was removed from the Monkey House on October 16th, 1907.

The history of this case, a male *Cercocebus fuliginosus* (Number 59), is interesting, not only because it was one of the first lot tested, but as an example of the need for unceasing vigilance. It reached the Gardens on March 29th, 1905, and had a temperature taken almost daily until June 28th, the range being from 100.6° to 103.8° . On the last date it was injected and gave a twenty-four hour temperature which appears good, but not being fully understood the animal was held over and reinjected on August 8th, at which time it was passed, again on a twenty-four hour record. In January 1906 it seemed unwell and was returned to the Laboratory for retesting, on which occasion the forty-eight hour chart was good, with trifling irregularities. It was kept under observation until March 6th, when it was returned to the Monkey House. Later in that month three others of the same species, originally passed in December 1905, were removed for retesting and found to be tuberculous, one of them (No. 62) having been the source of infection, as is indicated by present reading of the charts. Number 59 remained on exhibition in apparently good health for nineteen months, until October 16th, 1907, when it was removed to the Laboratory, dying three days later with general tuberculosis. After March 1906 this animal was not exposed to infection from other monkeys, and it is probable that it contracted the disease at that time from its three cage-mates, which were found to be tuberculous several weeks after its return.

Text-fig. 4.

Chart D.

*Lemur varius* ♀ adult.

Non-tuberculous temperature charts. Unbroken curve taken April 9th-11th, 1907;
broken curve taken July 1st-3rd, 1907.

Progress of the disease is usually much more rapid with monkeys than in this subject, and it is of course possible that it may have been a sporadic case communicated by human agency.

It cannot be said that the results reached with lemurs are equally exact. Indeed, at the present time, we are not disposed to rely much upon the charts in this group, except in cases of positively bad reaction. The greater frequency of doubtful cases here, than with monkeys, is primarily due to the greater amount of normal individual irregularity, especially in regard to the night drop. This is true even of diurnal species, as the genus *Lemur*, in which it is sometimes well marked, at others absent. To illustrate this two post-injection curves are given in Chart D (text-fig. 4, p. 87), of a female *Lemur varius*, on the first of which, taken in April 1907, had she been a monkey she would have been unhesitatingly condemned. In July she gave a good chart, differing from monkeys only in somewhat advancing the hour of the night minimum. She died September 8th, without any trace of tuberculosis.

There is some reason to believe that on the whole lemurs are less susceptible to infection through the usual channels than monkeys, though by no means immune.

At the present time, after three and a half years of systematic observation, the findings we believe to be justified by the fact that more than a year has passed without evidence of the existence of tuberculosis in the Monkey House, are these:—

1. In every case where a positive reaction has followed injection we have found tuberculosis on autopsy.

2. In negative charts, where no rise of temperature appears, nor perturbation of the daily rhythm, we have had no reason to believe that the disease exists. It has been absent in every such case after a forty-eight hour observation, where animals have subsequently come to autopsy.

3. In intermediate charts, neither positive nor negative, safety lies in nicety of judgment on the part of the observer, this being mainly a matter of experience. But a very small percentage of such cases have been tuberculous.

4. In very advanced cases of general tuberculosis the usual reaction does not always follow injection, but we have found such cases to be indicated by a notable drop in temperature, and proved by early death.

The difficulties in the way of applying the temperature reaction test generally throughout a zoological collection are obvious. The effort, risk, and various uncertainties involved in the frequent handling of large and powerful ungulates or carnivores, to procure the indispensable data, are so great that it is probably impossible.

In this aspect the eye test of Calmette, and skin tests, such as that of Lignières, seemed to be of some promise; but it is unfortunately true that experiments made by the present pathologist, Herbert Fox, M.D., with these tests upon monkeys known to be tuberculous, have not fulfilled expectations.

We are naturally led to the general subject of mammalian

temperatures, and a few notes may be given consistently with the purpose of this paper, together with a list of temperatures that have been taken with a view to possibly more extended work with tuberculin.

By artificially causing monkeys to turn night into day in all that concerned their activity, Simpson and Galbraith reversed the daily curve of temperature, the low point occurring in the afternoon, the high point in the early morning. This result, together with the irregularities we have found in diurnal lemurs, led me to observe the course in two nocturnal species: *Perodicticus potto*, in which the record for twenty-four hours proved to be: 3 P.M., 97.4°; 7 P.M., 99.2°; 11 P.M., 100°; 3 A.M., 99.8°; 7 A.M., 98°; 11 A.M., 97.6°; 3 P.M., 97.8°: and *Galago senegalensis*, in which the 3 P.M. record was 100.6°, the 3 A.M. 102.6°. A single observation previously made on *Galago crassicaudatus* at 3 P.M. gave 98.8°. This being low for primates, it is probable that it is near the minimum point in the daily curve of this species also, and that the record obtained from the Potto represents the normal in nocturnal lemurs, corresponding in its main features with Simpson and Galbraith's reversed curves in monkeys, the chief difference being that both high and low points come rather earlier.

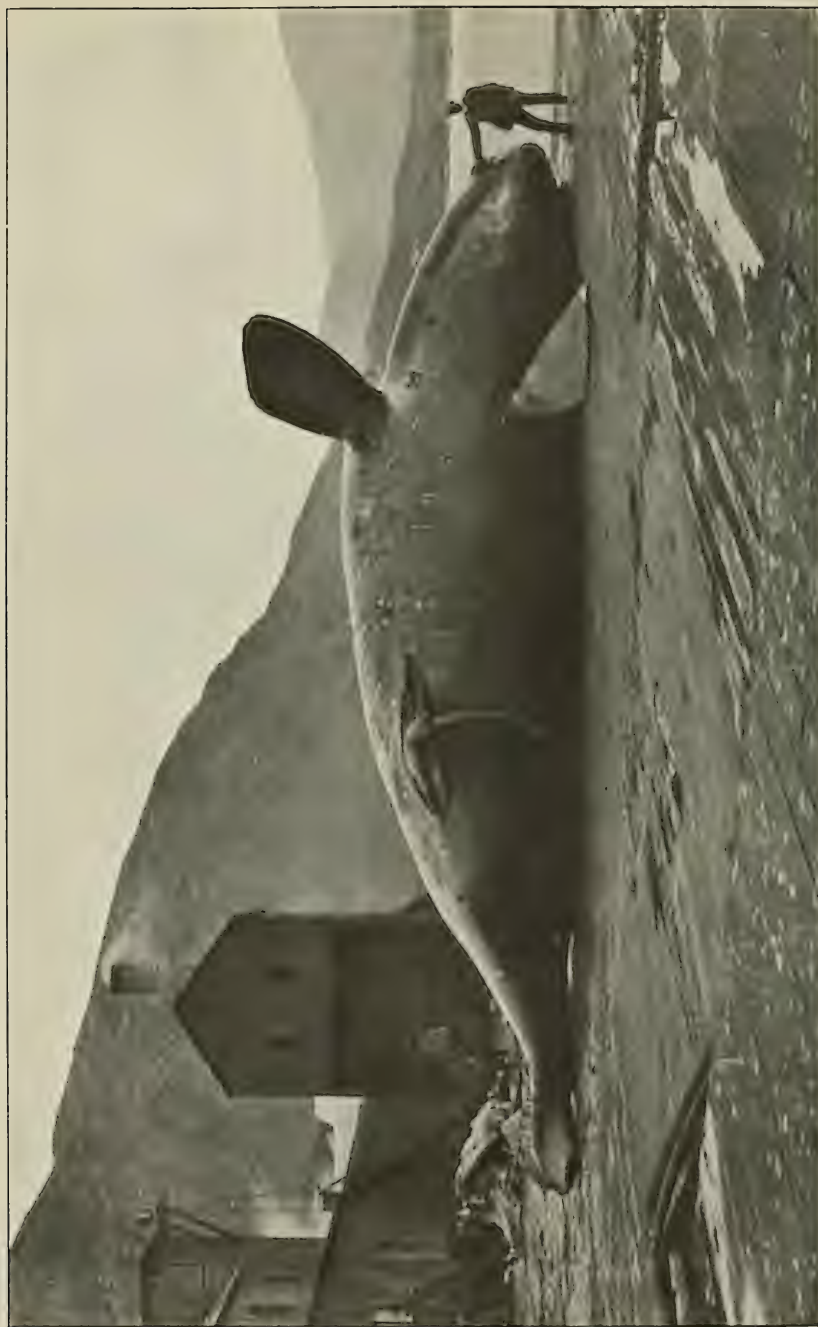
It seems, therefore, that the temperature drop in primates is an easily induced physiological result of decreased activity, which reaches its lowest limit during the period habitually allotted to sleep, and that the above condition should also be true of the night-monkeys, *Nyctipithecus*, but conclusions from five records taken from two examples of *N. trivirgatus*, about 3 P.M., are obscured by their irregularity. These were 102.2°, 101.5°, 100°, 99.8°, 99.4°. Further investigation of the complete curve in this genus will be of interest when occasion offers.

The temperatures following were taken with tested thermometers, and nearly all were checked by three observers. Whether or not, or to what extent, they were affected by excitement, as in monkeys, can be determined only by a more extensive series of observations than we have yet been able to undertake. The records were taken between 10 A.M. and 4 P.M. The temperature of the building in which the kangaroos were kept was 50°, the others ranged from 63° to 67°, but, excepting primates, within these limits neither the hour nor the surrounding temperature had any perceptible influence in the many cases where the same animal was tested repeatedly under different conditions.

Bearing in mind, however, the reversed daily curve in night-lemurs, it is significant to observe that animals of known nocturnal habit, such as *Cercoptes*, *Arctictis*, *Paradoxurus*, and *Mephitis* among carnivores, and *Peromyscus*, *Dipodomys*, *Capromys*, and *Dipus* among rodents, give afternoon temperatures distinctly lower than is common in diurnal species of their respective orders.

	Number of Specimens.	Maximum.	Minimum.
PRIMATES.			
Nyctipithecus trivirgatus ♂ ♀	2	102·2°	99·4°
Hapale jacchus ♂	2	102·8	102
Perodicticus potto ♂	1	97·4	
Galago crassicaudatus ♂	1	98·8	
„ senegalensis ♂	1	100·6	
CARNIVORA.			
Nasua rufa ♂	1	102·6	98·8
„ narica ♂	1	100·8	
Procyon cancrivorus ♂	2	100·2	99·2
„ lotor ♂	1	103·4	
Cercoptes caudivolvulus ♂	1	97·5	
Bassaris astutus ♂	1	100·2	99
Viverra megaspila ♂	1	100·5	
Viverricula indica ♀	1	102	
Arctictis binturong ♂	1	99·2	
Paradoxurus niger ♂	1	98·8	
„ hermaphroditus ♂	1	97·8	
Nandinia binotata ♂	1	101	
Herpestes mungo ♂	1	103	
Mustela furo ♀	1	102·2	
Galictis barbara ♂ ♀	2	105·6	101·2
„ vittata ♀	1	101	
Mephitis mesomelas ♂ ♀	2	97·8	97·4
Angora Cat ♂	1	101·2	
RODENTIA.			
Dipodomys spectabilis ♂	1	99·4	
„ ambiguus ♂	1	96·8	
Dipus jaculus ♂	1	99·2	
Peromyscus texensis ♀	1	97·8	
Capromys pilorides ♂	1	98·4	95·6
Myopotamus coypus	1	101·8	99
Dasyprocta azarae ♂	1	102·4	102
„ prymnolopha ♂ ♀	2	102·2	101·6
„ aguti ♂ ♀	2	102·2	100·2
„ acouchy ♀	1	102·2	101·5
PROBOSCIDEA.			
Elephas indicus old ♂	1	97·5	96·2
„ „ old ♀	1	97·5	97·2
„ „ young ♀	1	97·8	96·4
UNGULATA.			
Mazama rufa ♀	1	100·8	
Cervulus muntjac ♂	1	101·4	
Anoa depressicornis ♂	1	102	
EDENTATA.			
Cholepus hoffmani	1	94·2	
Dasybus sexcinctus ♀	1	93·4	90
„ novemcinctus ♂ ♀	2	93	91·6
MARSUPIALIA.			
Didelphys virginiana ♂	1	94·4	90·8
Dasyurus maculatus ♂ ♀	2	93·8	90
Phalangista vulpina ♂ + ♀	4	97·8	91·6
Macropus giganteus ♀	1	96·8	94·4
„ robustus ♂ ♀	2	95·2	
„ ruficollis ♂	1	96·4	
MONOTREMATA.			
Echidna aculeata ♂*	2	87	86

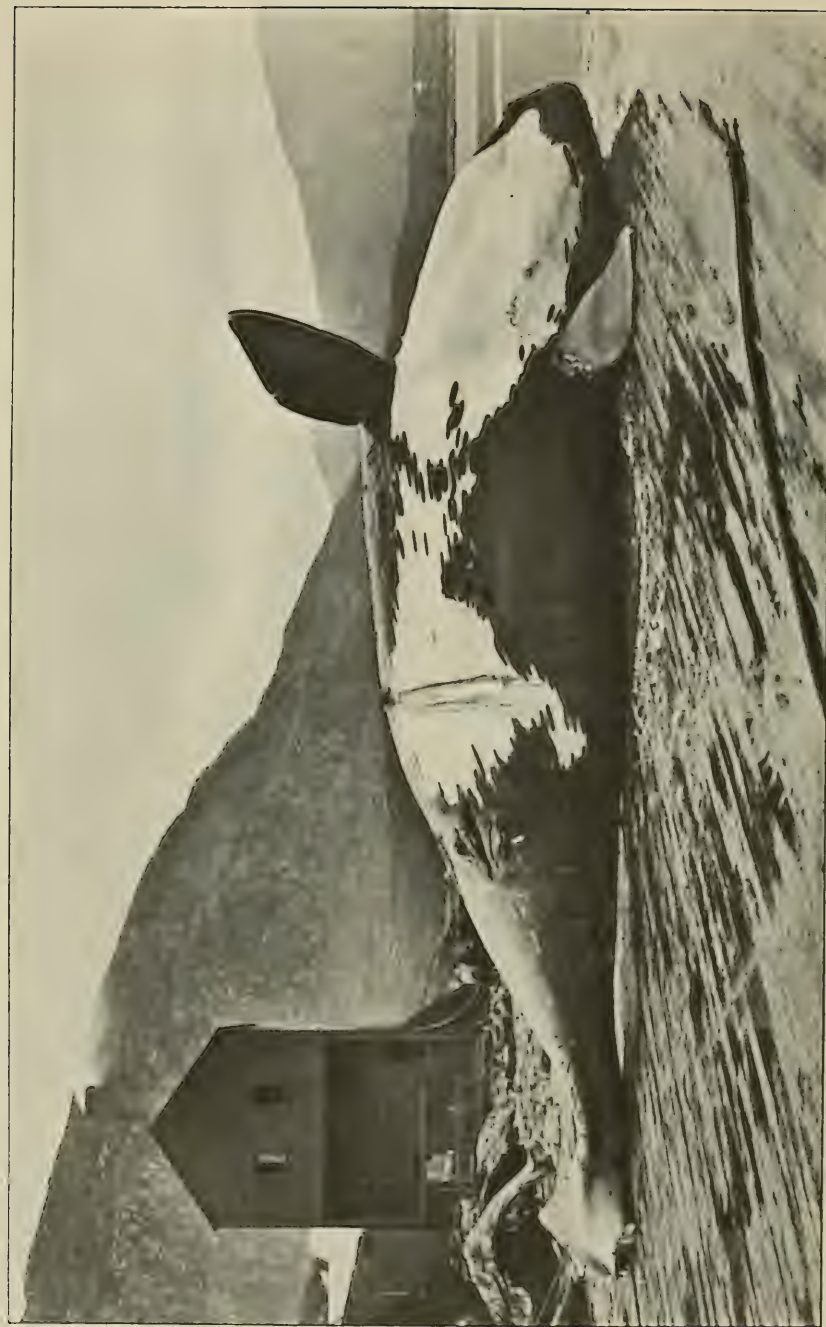
* R. Owen (P. Z. S. of London, 1845, p. 81) gives the temperature of the echidna as 85°.



BALÆNA GLACIALIS.



BALÆNA GLACIALIS.



BALÆNA GLACIALIS.

5. A few Notes on the Whale *Balæna glacialis* and its Capture in Recent Years in the North Atlantic by Norwegian Whalers. By Prof. R. COLLETT, F.M.Z.S.

[Received December 12, 1908.]

(Plates XXV.–XXVII.*, and Text-figure 5.)

Whales captured 1889–1908.—In our own day, the Nordkaper is not known to have been observed within the Norwegian area.

Since 1899, however, Norwegians have intermittently carried on whaling of this species in the sea to the east of Iceland and round the Faroe Islands, the Shetlands and the Hebrides, where the Nordkaper has appeared almost every summer in small companies, or sometimes in large schools.

In the course of twenty years, namely from 1889 to 1908, Norwegian whalers have in this way captured about 80 of these whales in the above-mentioned parts of the North Atlantic.

The numbers in the different years have been as follows:—

- 1889. In April the first specimen was taken on the European side of the Atlantic, to the east of Iceland. This was a female, with a total length of 43 feet (13·1 metres); the length of the head was 3450 mm. (thus being nearly one fourth of the length of the body).
- 1890. Seven specimens were taken round Iceland; a skull of one of these (total length 3920 mm.) and some baleen being preserved in the Christiania Museum.
- 1891. In all 10 specimens were killed off Iceland, several of them being caught about 50 miles to the west of that island. (Skeletons of these are in the Christiania and Bergen Museums.) One of them was a male, having a total length of about 47 feet (14·4 metres), the skull measuring 3910 mm. in length, or rather more than one fourth of the entire length of the body. Another was a female with a total length of 43 feet (13·1 metres).
- 1892. One specimen captured off the Faroe Islands.
- 1894. Two specimens captured off Iceland.
- 1897. Two specimens captured off Iceland, one of them being a female with a length of 46 feet (14 metres).
- 1898. One specimen taken near the Faroe Islands (a female accompanied by a young one).
- 1902. One specimen taken off Iceland.
- 1903. One specimen taken off the Faroe Islands, and three specimens off Iceland, four altogether. Among these

* For explanation of the Plates see page 98.

last was a female, taken in August (length 54 feet, or 16·4 metres), which contained a fœtus about 1 metre in length; another was scarcely more than a half-grown young one.

1904. Two specimens were captured to the south-east of Iceland.
1905. (One was wounded off St. Kilda, but escaped.)
1906. Six killed, and more seen (in company with *Balænoptera borealis*) off the Hebrides, between the 13th June and the 4th August.
1907. A large number seen, and 24 killed off the Hebrides. The latter were of both sexes; all the females were gravid.

Two specimens were also taken off the Faroe Islands, making 26 in all.

1908. Several hundred seen, and 20 killed off the Hebrides, between June 18th and July 9th. Those killed were of both sexes; none of the females were gravid.

Five specimens were also captured off Inishkea, Ireland, between June 8th and June 13th (among them one female and a young one), making 25 specimens in all.

Whaling in the Hebrides, 1906–1908.—The largest capture of Nordkapers in the present day took place during the past three years, when a single company (at Station Bunevenader, Harris), came across large schools of them in the sea off the Hebrides, and brought back 50 (6 in 1906, 24 in 1907, and 20 in 1908). About these I have received some particulars from the manager, Capt. Carl Herlofsen.

The six specimens in 1906 were taken on June 13th and 15th, July 18th and 31st, and August 4th (two on July 31st).

In 1907, the first two specimens were captured on June 13th. On June 15th another two were taken, and the rest later in the same month, ten in all; in July fourteen were captured, the last on the 26th July. The 11th July was a successful day, six whales being captured, four of them in the course of six hours.

In 1908, on the 13th and 22nd June, two specimens were taken, the remaining 18 being taken between the 3rd and the 9th July. On two occasions five whales were killed in one day, namely on the 4th July (all males) and on the 7th July (three males and two females).

The five specimens that were killed the same year off Ireland had probably been on the whaling-ground at the beginning of June. On the first day of whaling, the 8th June, one Nordkaper was taken, and the remaining four were caught within the next few days. They were all separate, and no schools were observed.

Size.—Among the 24 specimens captured in 1907, males and females were in equal numbers; while of the 20 in 1908, twelve were males and eight females.

The specimens of the latter year averaged rather smaller than those of 1907. The females seem to be larger on the whole than the males; and the largest of all the specimens was a female, whose length was 50 feet (15·2 metres).

Text-fig. 5.



Balæna glacialis, male; from the Hebrides, July 6th, 1908.

The 24 specimens in 1907 were of the following length:—

MALES (12).		FEMALES (12).	
English feet.		English feet.	
48	(14·6 metres)	49	(14·9 metres)
47·5	(14·4 ")	48·5	(14·7 ")
47	(14·3 ")	48	(14·6 ")
46·5	(14·1 ")	48	(14·6 ")
46	(14 ")	47·5	(14·4 ")
46	(14 ")	47·5	(14·4 ")
46	(14 ")	47	(14·3 ")
45·5	(13·8 ")	47	(14·3 ")
45	(13·7 ")	47	(14·3 ")
45	(13·7 ")	46	(14 ")
45	(13·7 ")	44·5	(13·5 ")
43	(13·1 ")	44	(13·4 ")

Most of the 12 males thus had a length of from 46 to 47 feet, the average being 45·8 feet (13·9 metres).

Among the 12 females, the length was most frequently between 47 and 48 feet, the average being 47 feet (14·3 metres). In girth, the males measured 33·7 feet, the females 36·6 feet*.

The 20 specimens in 1908 were of the following lengths:—

MALES (12).		FEMALES (8).	
English feet.		English feet.	
47	(14·3 metres)	50	(15·2 metres)
47	(14·3 ")	49	(14·9 ")
47	(14·3 ")	47	(14·3 ")
46	(14 ")	46	(14 ")
46	(14 ")	43	(13·1 ")
46	(14 ")	43	(13·1 ")
46	(14 ")	43	(13·1 ")
44	(13·4 ")	31	(9·45 ")
42	(12·8 ")		
42	(12·8 ")		
37	(11·2 ")		
36	(10·9 ")		

Thus in 1908 the length of the 12 males was between 36 and 47 feet, the greater number of them being from 42 to 46 feet. The average length was 43·8 feet (13·3 metres).

Of the 8 females, one was 50 feet in length, and another, a young one, 31 feet, the remainder being between 43 and 49 feet. The average length this year was only 44 feet (13·4 metres).

The females in 1908 measured on an average 35 feet (10·6 metres) in girth, and the males 33·8 feet (10·3 metres), but the girth varied considerably. Among the males this year, there was one specimen that had a total length of 46 feet, and measured exactly the same in girth, namely 46 feet. Although it was not greatly inflated with gas (it had been dead only twenty-four hours), it was almost as round "as a ball" when it lay on the beach.

Colour.—There is no great difference to be found in colour between male and female.

A uniform black must be considered to be the typical colour, covering the entire body without any great differences of shade. In some specimens, however, more or less of the ventral surface was white. The boundary of this white colour was clearly defined against the black sides; in many specimens the white area was somewhat constricted in the middle, and in parts, especially towards the sides, was covered with oblong, black spots.

* Haldane, Ann. Scot. Nat. Hist., April 1908, p. 69.

The white-coloured belly occurred in both males and females.

Of the 6 specimens captured in 1906, one adult specimen and one young one were white-bellied. Out of the 24 captured in 1907, six specimens, or one fourth of the whole number, were white-bellied. Of the 20 specimens captured in 1908, only two were white-bellied (one male and one female). Thus 20 per cent. of the 50 specimens captured in the course of the last three years have been white-bellied.

None of the five specimens caught in 1908 off Ireland was white-bellied. The specimens were of both sexes, and the largest measured about 50 feet in length.

In the black colour on the belly in most, though not all, of the specimens, a large number of white stripes occurred, running in all directions, and measuring up to one metre in length and about 50 mm. wide. It is possible that these stripes may have been produced by the rubbing of the animal against the bottom when following the plankton-crustaceans upon which it feeds, and that they are of the same origin as those described in certain old specimens of *Mesoplodon bidens* and others.

The *pectorals* were black on the whole, both in the black- and in the white-bellied specimens, though often with a faint white marbling on the upper surface and the margin.

The *baleen* is black, both in the white-bellied specimens and in the black, though in some specimens a few of the foremost plates were white.

The number of plates was stated to be about 250 on each side. The bristles were also all black, and almost as fine as silk. One of the longest plates, which was presented to the Christiania Museum, measured 2225 mm. in length; the bristles were longest at the tip, where their length was 450 mm., but elsewhere measured about 250 mm. The longest plate that has been measured (Iceland 1903) had a length of 2700 mm.

The peculiar wart-like excrescences are situated in irregular rows along the upper and lower mandibles. The largest of these, as in *B. australis**, are at the tip of the upper jaw, where several sometimes join, and together form the largest "bonnet"; then one on each side of the tip of the lower mandible, and finally one immediately above each eye.

The *value* of a Nordkaper at the present time is from about 6000 to 10,000 kroner (£330 to £550). The blubber, which in some specimens is of a pale pink colour, has a thickness of about 260 mm. The amount of oil it contains varies from 10 to 30 barrels (of the first quality).

In the two young specimens mentioned above as captured in 1907, the blubber was pure white; the animals were exceedingly fat, and yielded about 30 barrels of oil each.

The weight of baleen in a full-grown specimen is from 250

* Lönnberg, Kgl. Sv. Vetensk.-Akad. Handl. B. 49, no. 5, p. 45 (Oct. 11, 1906).

to 330 kilogrammes, and is valued at about 6800 kroner (£375). From four full-grown whales, about one ton of baleen is obtained, which will thus fetch about 27,000 kroner, or £1500*. A single one of the longest plates of whalebone is worth about 38 kroner (£2 2s.).

Habits.—Every year of the whale-fisheries in the Hebrides, the whales kept almost to one place, always occupied in seeking food among the pelagic crustaceans. In 1906 they stayed nearly seven weeks, but they were then more scattered, and appeared more irregularly.

In 1907 they were on the ground for about six weeks, during which time they appeared sometimes separately, sometimes in small schools. The school that took up its quarters in this spot in 1907, consisted of at least 100 whales.

In 1908, the plankton-bearing currents probably flowed nearer land than in 1907, for the whales might be met with quite in the shallow water between islands and rocks. Their stay this year was of only three weeks' duration.

The schools this year consisted of several hundred, and, as already mentioned, the boats of the Station several times captured from two to five whales a day.

In 1907 the school was unaccompanied by any other species of whale; but in 1908 they came with hundreds of Rudolphi's Rorquals (*Balenoptera borealis*), which were just on their way north†.

The five specimens killed off Ireland in 1908 were also accompanied by *B. borealis*.

The Nordkaper is not timid, and is on the whole easy to approach. The harpoon used is a bomb-harpoon of the kind used in the Arctic Ocean. As the blubber is of considerable thickness, the harpoon should if possible be discharged at close quarters. If it strikes in the right place, the whale soon dies; but if it is only wounded, it becomes very violent in its movements, to the no small danger of the boats, although it does not attack them; it plunges round in the water like a ball, and often gets the line wound several times round its body.

Notwithstanding the thick build of its body, it is able to bend it until the head nearly meets the flukes.

It is fond of lying quietly on the surface of the water; and it moves slowly, with its blow-holes above water. The jet these sent up could be seen from a considerable distance, and was about 5 metres in height. It was comparatively thicker than that of a Common Rorqual (*B. physalus*); a closer view shows it to be distinctly formed of two jets falling to different sides.

* The 24 specimens caught in 1907 yielded a total of rather more than 6 tons of baleen, of which the value was more than £9000 (163,000 kroner).

† *B. borealis* (Norwegian "Sei-hval") appears annually in larger or smaller numbers in the plankton-currents off the coasts of Tromsø and Finmark, generally staying from the middle of June to the middle of August.

As a rule, it blows five or six times in succession, and then remains under water for from ten to twenty minutes.

It dives almost perpendicularly, and therefore in diving shows the whole of the flukes. It sometimes leaps high in the water, but it has never been seen to leap quite out of the water.

It has never been heard to make any sound.

Its food, both in the Hebrides and off Iceland, was found to be exclusively pelagic crustaceans (the "krill" of Norwegian whalers), a Euphausiid about half an inch long, probably *Boreophausia inermis*.

Parasites.—All specimens were infested with thousands of *Cyamus* (the "lice" of whalers), which are especially found in the furrows of the excrescences along the jaws. They may also occur around the genitalia and scattered over the body.

Young.—Among the numbers that have frequented the waters round the Hebrides during the last three years, no small young ones were found. The three smallest captured had total lengths of 31, 36, and 37 feet (9·45, 10·9, and 11·2 metres). One of these young ones was white-bellied, and its baleen was of a lighter shade of colour than that of the black-bellied.

Propagation.—Three specimens were observed just before copulation on the 7th July, 1908. A female was lying on her back, and on each side of her lay a male with extended genital member, when the vessel came upon them and secured the female.

The twelve females killed in 1907, in June and July, in the Hebrides, were all gravid. The foetuses were all more or less of the same size, having a length of from 1 to 1½ metre; their colour was always pale blue, with no trace of white on the under surface.

In the largest foetus, the first rudiments of baleen had begun to appear.

In 1908, eight females were killed in the Hebrides, but, as previously stated, none of them was gravid. It is therefore possible that the gravid females go in separate schools.

There is also an account of a foetus of about 1 metre in length found in the summer of 1903 off Iceland (in a female 54 feet in length, or about 16·4 metres).

From the above observations the following facts appear:—

Balæna glacialis may at present be met with in the summer in the North Atlantic in schools of 100 or more.

The length of most of the full-grown males captured in the years 1906–1908 was from 46 to 47 English feet (up to 48 feet), or from 14 to 14·3 metres (up to 14·6); that of the females generally from 47 to 48 English feet (up to 50 feet), or from 14·3 to 14·6 metres (up to 15·2 metres).

The greatest length was that of a gravid female, and amounted to 54 feet, or 16·4 metres (Iceland, 1903).

Of the 50 specimens captured in the summer of 1906–1908 in the Hebrides, about 10 per cent. were white-bellied.

Proc. Zool. Soc.—1909, No. VII.

Copulation may take place in the beginning of July, and gravid females have been found in June and July, with fœtuses of about 1 metre's length.

Their food in the summer months in the North Atlantic is (as far as has been observed) plankton-crustacea.

EXPLANATION OF THE PLATES.

PLATE XXV.

Balæna glacialis, male, from the Hebrides, July 8, 1908.

PLATE XXVI.

Balæna glacialis, male, from the Hebrides, July 6, 1908.

PLATE XXVII.

Balæna glacialis, female, white-bellied, from the Hebrides, July 6, 1908.

February 2, 1909.

FREDERICK GILLETT, Esq., Vice-President, in the Chair.

Mr. C. Tate Regan, M.A., F.Z.S., exhibited specimens of the Char of Lough Melvin (*Salvelinus grayi*, Günth.) and of the Char from a little loch under Ben Hope, Sutherlandshire, recently described by him under the name *Salvelinus maxillaris*. He pointed out the differences between the two forms, and called attention to the interest attaching to the study of this too much neglected group of British freshwater fishes.

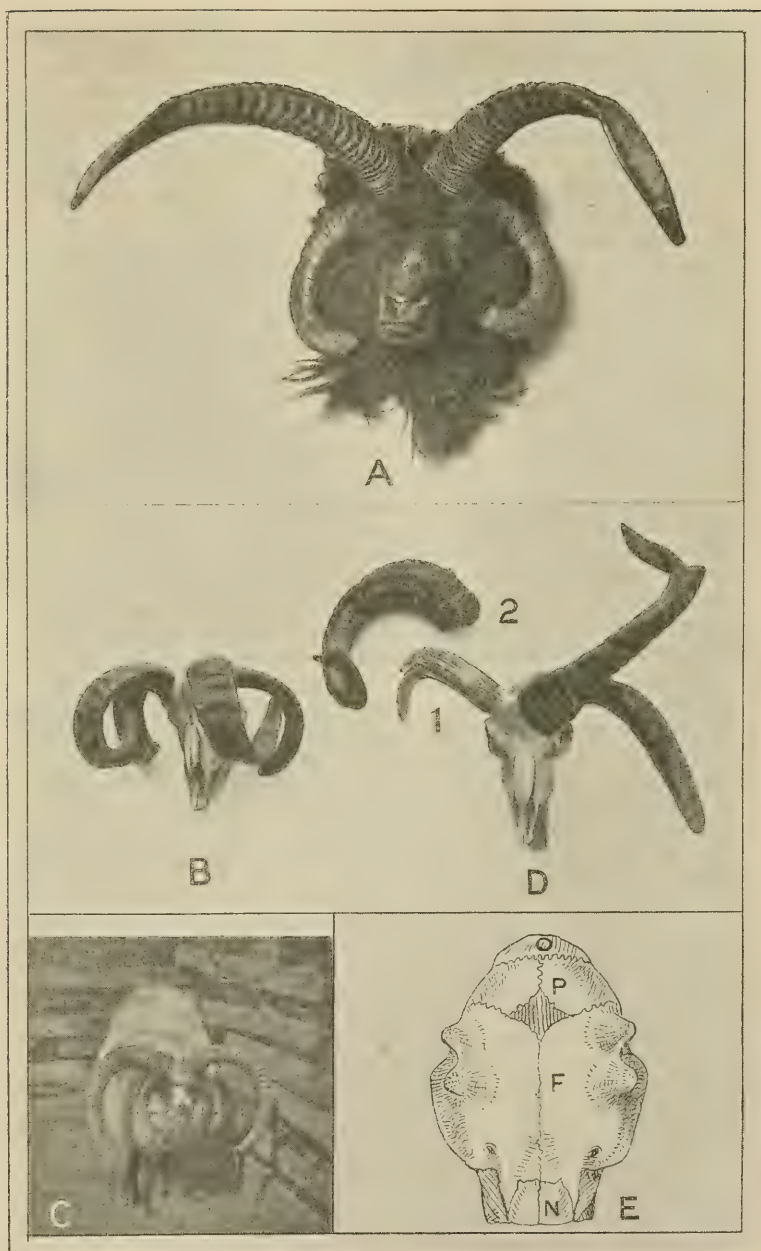
Mr. R. E. Holding exhibited several skulls and photographs of the St. Kilda or Hebridean Four-horned Sheep, and made the following remarks concerning the horns in this variety:—

“That there are several well-defined breeds of the domesticated Sheep which carry normally four horns is now well known.

Explanation of Text-fig. 6 (see opposite).

- A. Head of St. Kilda Ram, showing wide type of the horns. Length of upper horns $18\frac{1}{2}$ inches each.
- B. Ditto, showing the narrow or more contracted type. The upper horns forming almost a complete circle; in both specimens the lower horns had to be cut to prevent their growing into the jaw.
- C. Photograph from life (by E. M. Machugh) of an exceptionally good head of a well-known Scotch black-faced four-horned breed, which was established some thirty years ago from an odd Ram Lamb which occurred in the flock. The owner taking some interest in the matter, was enabled by selection to cause the variety to become permanent, some remarkable heads being the result.
- D. Skull from the same flock as B, showing two separate horn-pedicles or supports (1), covered by one sheath (2), indicating that these supernumerary horns have their origin in duplicated centres of the frontal bone. The upper left pointing backwards is an unusual variation.
- E. Upper part of the skull of a St. Kilda Ram Lamb at six weeks old, showing an early stage in division of the bony pedicle which supports each horn. O, occipital; P, parietal; F, frontal; N, nasal.

Text-fig. 6.



Heads etc. of Four-horned Sheep.

The St. Kilda or Hebridean and the South-African varieties are the better known, but there are also an Indian variety, of which several specimens are living in the Society's Gardens, having some slight variations, and a local breed of the well-known Highland "Black face," which also bear four horns. The St. Kilda is entirely black, the fleece being dark brown; the South-African form is piebald on the face and legs, with black irregular marks on the fleece; the Indian has spotted face and legs and white or grey fleece; and the Scotch variety has characteristic face-markings and long-stapled wool.

"Although at first there seems to be a somewhat perplexing irregularity in the form and pitch, as it were, of the horns of these Sheep, there can, I think, be seen a fairly constant type which separates the horns of the St. Kilda Sheep from those of other varieties. Upon looking over a considerable series, it is apparent that there are two distinct types—one in which the median horns are directed well forward in a semicircular curve, as in A, text-figure 6 (p. 99), and the other, B, in which the median horns take a much smaller curve over the face. I have not noticed an intermediate stage in this breed. The lateral horns spring at almost right angles from the skull, and grow at times so close inwards that the points would penetrate the skull if not cut. The median horns of the South-African variety are usually erect, or, if curved, take a backward inclination, rarely directly forward as in the St. Kilda form. The lateral horns are also of wider curve, and so grow clear of the head. The Highland variety follows very closely the Hebridean form, as shown in C.

"In the same flock of St. Kilda Sheep some variety may occur in the number of the horns, as indicated by D, which come from the same source as A.. This is apparently due, not to any arrest in the growth of the bony horn-bearers, but to their fusion under a single horn-sheath, as indicated by the specimen. These super-numerary horns are not due to an antero-posterior cleavage, *i. e.* from apex to base, but to segmentation of the centres of ossification of the frontal bone, as indicated by the skull of a Lamb, E, at six weeks old."

Mr. Malcolm Maclaren, through Mr. C. Davies Sherborn, F.Z.S., called the attention of the Fellows to an account of a fight between a Whale and a Swordfish observed by the crew of the fishing-boat 'Daisy' in the Hauraki Gulf, between Ponui Island and Coromandel, as reported in the 'Auckland Weekly News,' 19th Nov., 1908. A cow whale and her calf were attacked by a 12 ft. 6 in. swordfish, the object of the fish being the calf. The whale plunged about and struck in all directions with her flukes. Occasionally the fins of the swordfish were seen as he rose from a dive, his object apparently being to strike from below. For over a quarter of an hour the whale circled round her calf, lashing furiously and churning up the water so that the assailant was unable to secure a good opportunity for a thrust. At last,

after a fruitless dive, the swordfish came close up and made a thrust at the calf, but received a blow from the whale's flukes across the back, which apparently paralysed it. It was killed and hauled on board the boat without difficulty, while the whale and calf went off towards Coromandel with splashings and plungings. The whale's blow had almost knocked off the back fin of the swordfish and heavily bruised the flesh around it. No threshers accompanied the swordfish.

Dr. C. W. Andrews, F.R.S., F.Z.S., gave the following account of his visit to Christmas Island in 1908, and illustrated his remarks with lantern-slides:—

"Christmas Island in the Indian Ocean (S. lat. $10^{\circ} 25'$, E. long. $105^{\circ} 42'$) lies some two hundred miles south of Java, which is the nearest land. It has an area of about forty square miles, and its highest point is 1200 feet above the sea-level. The island consists mainly of coral-limestones resting on a basis of volcanic rock interstratified with foraminiferal limestones; the whole surface is thickly covered with forest and jungle. The fauna and flora of this isolated spot have been the subjects of numerous papers, a list of which up to the year 1900 is given in the 'Monograph of Christmas Island,' a volume which contains a detailed account of the collections which were made by me during my former visit in the years 1897-8. Since that date the island has been visited by Messrs. Ridley and Hanitsch of Singapore, and the former has published an interesting account* of the flora, to which he was able to make a considerable number of additions. Almost up to the date of my first visit the island had been uninhabited, and was only visited by ships on very rare occasions; but since then, owing to the quarrying and export of the valuable deposits of phosphate of lime, a considerable population has been imported, and many ships call either to bring stores or to ship cargoes. The consequence of this is that many animals and plants have been introduced from time to time, and it was for the purpose of investigating the effect of these introductions on the native flora and fauna that, at the suggestion of Sir John Murray, I revisited the island in the autumn of last year, remaining there about three months. The changes that have taken place are, as might be expected, chiefly noticeable in the immediate neighbourhood of the settlement and quarries, while the rest of the island, although traversed by roads in several directions, is practically unchanged. To this general statement there is, however, at least one important exception, and that is that the two species of native rats seem to have become totally extinct. At the time of my former visit these animals swarmed over the whole island, one, *Mus macleari*, being found practically every-

* "The Botany of Christmas Island," Straits Branch, Royal Asiatic Society Journal, June 1906, p. 121.

where; the other, *Mus nativitatis*, more adapted for burrowing, was for the most part confined to the higher ground. Last year, in spite of continual search, not a single specimen of either species could be found in any part of the island. This complete disappearance of two such common animals seems to have taken place within the last five or six years, and to have been the result of some epidemic disease, possibly caused by a trypanosome, introduced by the ship-rats. These are a variety of *Mus rattus*, and have been introduced in considerable numbers, though they do not seem to have spread to the remoter parts of the island at present, at least to any great extent. The disappearance therefore of the native forms cannot be due to direct competition with the intruders, but must be the result of disease, a conclusion supported by an observation made by the medical officer, Dr. McDougal, who told me that some five or six years ago he frequently saw individuals of the native species of rats crawling about the paths in the daytime, apparently in a dying condition. I hope that it will be possible to obtain information as to whether any trypanosome or other pathogenic organism occurs in the blood of the imported rats.

"Of the other native mammals the shrew (a variety of *Crocidura fuliginosa*) is probably also extinct, at least no specimen was either seen or heard during my visit. The large fruit-bat (*Pteropus natalis*) is more numerous than formerly, at least near the settlement, probably in consequence of the much larger number of fruit-trees now to be found there. Cats have been introduced, and are becoming numerous; in some cases they have taken to the woods, and occasionally cause great destruction among the poultry which are reared in large numbers.

"The native land-birds all seem to be as numerous as formerly. The large fruit-pigeon (*Carpophaga whartoni*), which is used for food, is protected during the breeding-season, and at other times the number killed is limited so far as possible. These birds have not yet acquired any fear of man, and allow themselves to be snared by hand as easily as ever. The frigate-birds do not nest in the neighbourhood of Flying Fish Cove in anything like such numbers as formerly, but are still very numerous elsewhere. The yellow tropic-bird (*Phaethon fulvus*) seems to have increased in numbers. No introduced bird has obtained any footing on the island.

"No changes of importance were noticed among the native Invertebrates; but the large *Scolopendra*, of which a very few individuals were noticed during my first visit, is now much more numerous. Probably many insects have been introduced, but until my collections have been fully worked out, nothing can be said on this point.

"A large number of plants have been introduced, and probably the clearing of the forest and cutting of roads will enable them to spread much more rapidly in the future than they have done in the past. Already the papia and chillies have extended



PHYLLIUM CRURIFOLIUM.

Bale & Danielsson, L^{td}

their range considerably. In the clearings in Flying Fish Cove and on the shore-terrace it is interesting to note that nearly all the secondary growth consists of a small tree, *Melia azederach*, which at the time of my first visit was represented by two or three examples only, and these had most likely been introduced by man. In other parts of the island clearings are often occupied by great numbers of seedlings of *Inocarpus edulis*; this is one of the consequences of the extinction of the rats, which formerly fed largely on the fallen fruits of this tree.

"Much time was spent in collecting the marine fauna, especially of the reef at Flying Fish Cove, and I hope that reports on some of the groups will be published shortly."

The following papers were read:—

1. Preliminary Account of the Life-history of the Leaf-Insect, *Phyllium crurifolium* Serville. By H. S. LEIGH, Honorary Research Fellow in the University of Manchester.*

[Received December 23, 1908.]

(Plate XXVIII. †)

The present paper is intended to form a preliminary account of the life-history of a Leaf-Insect, *Phyllium crurifolium*‡ Serv. from the Seychelles Islands. I have had this species under observation during the past year, and although I have been able to note several facts of interest in connection with the development, many of the more important details remain to be worked out.

It was thought, however, that notwithstanding the fragmentary nature of my observations up to the present time, some account of this remarkable insect might prove interesting, and it is on this consideration that the following preliminary account has been written.

My study of *P. crurifolium* has been carried on in the Zoological Laboratories of the Manchester University, and also in the hot-houses at my own residence in Worsley.

I had neither sufficient material nor apparatus for making a complete study of the insect and its development during the past year. The work will be continued, however, during the coming season, and with abundant material at my disposal I hope to complete the details of the study and publish the results in a fully illustrated memoir.

During the autumn of 1907 I received a hundred ova and some

* Communicated by Professor S. J. HICKSON, F.R.S., F.Z.S.

† For explanation of the Plate see p. 113.

‡ Kirby (1904) includes this species in his genus *Pulchriphyllium*.

thirty young larvæ of *Phyllium crurifolium* from Mr. St. Quintin, F.Z.S., and it is owing entirely to his kindness in presenting them to me and also in furnishing me with a few of the more important suggestions as to the conditions necessary for successfully rearing them, that I have been able to observe the habits of the insects in confinement.

The eggs that I received were laid by insects which Mr. St. Quintin had reared during the winter of 1906 and 1907, and he is, I think, the first naturalist who has *bred* the Leaf-Insect in this country. The original stock was brought from the Seychelles to England in the spring of 1906 by Lord Crawford.

The genus *Phyllium**, which constitutes the tribe Phylliides and includes all the Leaf-Insects, comprises perhaps some of the most extraordinary of all living insects; their wonderful similarity to vegetable structures has often aroused the admiration of naturalists, but it is only upon gaining a more complete knowledge of their life-histories that we can fully appreciate this most astonishing example of "Protective Resemblance." It is not a matter of much surprise that the Leaf-Insects were thought at one time to be of a vegetable as well as of an animal nature. This imaginative belief has given rise to several peculiar ideas, and one prevalent notion amongst the people in those countries which these insects inhabit is, that the insect is in reality a changed leaf that has adopted the strange practice of walking (de Borre, 1883).

The genus of Leaf-Insects was thought in the time of Linnæus to consist of only one species; this was named *Mantis siccifolius* (1767), and was figured by Rösel (1749). Stoll (1815) gave figures of two species, whilst Serville (1839) mentions three species in his 'Histoire Naturelle des Orthoptères.' In 1843 Gray described thirteen species, many of which were new, and Westwood (1859) mentions fifteen species. Joly (1871) described more fully than any previous author the natural history and anatomy of *Phyllium crurifolium* Serv.; and later, in 1887, Brongniart gives a short account of the development of *Phyllium siccifolium* Linn. Since that time very little appears to have been written until 1903, when Morton's paper "Notes sur l'élevage des Phyllies" was published; and quite recently two short papers have been written by St. Quintin: one "Leaf-Insects in Captivity" (1907), and the other "Notes on the Life-history of the Leaf-Insect" (1908).

Apart from these, little work appears to have been done recently, and our knowledge of the life-history of the Leaf-Insect is still meagre.

The first living examples of *Phyllium* were brought to this country in 1854. The bringing of living specimens was attended with some difficulty, but Mrs. Blackwood, who was greatly

* Kirby (1904) includes three genera in his subfamily Phylliinae, viz. *Chitoniscus*, *Pulchruphyllium*, *Phyllium*.

interested in these strange insects whilst in India, attempted to bring some back with her; she received some eggs in 1854 which hatched in due course, and Murray (1856) gave an account of a specimen which was reared to maturity in the Royal Botanic Gardens of Edinburgh. Prior to this, I believe the transformations and habits had not been watched by any naturalist.

The *Phylliums* are peculiar to the Old World, being mostly confined to the islands of the Indian Ocean, and they would seem to have a special predilection for insular life. Several species inhabit the Seychelles and Ceylon, whilst others occur in Mauritius, Borneo, Java, Celebes, and the Philippines, and some are reported to extend as far as the Fiji Islands. One species, *Phyllium scythe*, is recorded from the mountainous regions of Northern India.

The eggs of the Leaf-Insect have been studied in Europe on several occasions: by Murray in 1855, Joly in 1871, Henneguy in 1890, and others—they all speak of their great resemblance to seeds. The egg of *Phyllium crurifolium* is about the size of a sweet-pea seed and resembles very closely the seeds of certain umbelliferous plants. Murray, speaking of *P. scythe*, says: "If the edges of the seed of the *Mirabilis jalapa* were rubbed off, the seed might be mistaken for the egg." The egg—which is in reality a capsule containing the egg—is of a brown colour, somewhat barrel-shaped, with five longitudinal ribs, all of which are equal distances apart, except two between which the space is wider. The surface of the egg is rough and cork-like, and there is usually an irregular row of small pits in the spaces between the longitudinal ribs. The large space is much smoother and flatter than the other portion of the egg, and in the centre there is a groove of an oval form extending almost from the apex to the base and enclosing a small scar or hollow which I believe has been compared to the hilum in seeds. At the apex of the egg a conical lid or stopper is attached, whilst the base is slightly concave.

The capsule of the egg appears, without the aid of a lens, to be of a rather fibrous nature, but when examined with a microscope the true porous texture is revealed. If, as Murray says, this outer covering had been of a firm substance, the embryo insect could not have received the amount of air and moisture necessary for its existence. Moisture and warmth are two extremely important factors in the development of *Phyllium*, and certainly if the eggs were surrounded with a compact substance the young insect could not develop. As in most Phasmidae, the eggs are not glued on to surrounding objects, but are deposited loosely and fall through the foliage to the ground where they remain for some time before hatching; they are retained for a few minutes between the gonapophyses of the female after their extrusion from the oviduct and are afterwards shot out to some distance. In some cases ova were found three feet or more from the female.

This habit of discharging the eggs no doubt ensures a better distribution of the offspring, as the females are extremely sluggish creatures, and if the eggs were simply dropped they would in all probability be clustered together in masses and fall an easy prey to their enemies.

It is necessary when rearing the *Phylliums* in captivity to provide abundant moisture as well as heat for the ova. They were placed in an orchid house where a temperature varying from 65°–85° F. was maintained, the atmosphere being also exceedingly moist.

Under these conditions the ova began to hatch about the end of August 1907, the first larva appearing on August 28th, and they continued to hatch very irregularly until the end of January 1908. Although the majority of the larvæ appeared during September, October, and November, I found that their emergence depended to a great extent upon a high temperature; none hatched unless the temperature exceeded 70° F. Morton and St. Quintin each speak of this irregularity in the hatching of the eggs, and the latter says that although his larvæ continued to emerge during several months, "the ova were all deposited between the 7th April and the 15th May."

I think it is very probable that the time passed in the egg stage is exceedingly variable and may be prolonged. In confinement embryonic development requires four to seven months for its completion. Apparently the larvæ emerge very irregularly in the Seychelles, for some were found in the early larval stages side by side with the adult insects.

The larva, when ready to emerge, pushes off the lid or stopper to which reference has already been made. When newly-hatched it is about 16 mm. in length and possesses the characteristic form of the *Phylliums*. The head and prothorax are reddish-brown; meso- and metathorax brown with a red dorsal line; flattened expansions of the abdomen reddish-brown, but marked with dark brown semicircular rings from the fifth to the tenth segments.

I found that the young larva takes no food until four days after hatching, and during this time it is rather active, moving about with a singular hesitating and staggering action, which is even accentuated if the insect is alarmed.

The plant upon which these insects principally feed is the *Psidium guava*, but in Ceylon they are said to feed also on the leaves of the tea and certain species of lemon trees.

This question of food probably offers one explanation for the young larvæ fasting a few days, as the chances are it would be extremely difficult for them (on emerging from the eggs lying on the ground) to climb up the stems of their food-plant through the thick and entangled vegetation and obtain food at once.

Not being able to procure any of the natural food-plants, I followed the example of Mr. St. Quintin and placed my young larvæ on oak leaves which I found they took to well; they require, however, to be provided with plenty of moisture, and to

ensure this, I sprayed them once a day with tepid water. It was most interesting to see the thirsty larvæ eagerly drinking the drops as they hung from the leaves and branches after the spraying.

As the autumn advanced the leaves of the oak became less nutritious, and it was necessary to find another substitute for the larvæ. Again following the advice of Mr. St. Quintin, I placed the larvæ on small bushes of the evergreen oak (*Quercus ilex*) and on this they settled down very well.

The rate of development, *i. e.* the time occupied between the deposition of the eggs and the appearance of the imago, depends very largely upon the temperature. I have not yet been able to work out the exact length of the various larval stadia, but have determined their approximate lengths, and I should think that under favourable circumstances the whole development would be completed in ten or eleven months.

The Leaf-Insect is Paurometabolous and corresponds to the general rule in the Orthoptera. The larvæ in all stages are on the whole similar to the adults and there is no very abrupt transition, development taking place by a gradual increase in size. In the newly-hatched larva neither tegmina nor wings are present, these being acquired during the later stages, but only attaining their full dimensions in the imago state. There is no pupal stage, the larva merely passing through a slight resting stage prior to its reaching the perfect condition. I found that there are six or seven larval stadia, so that the number of ecdyses is six or seven. Murray gave three as the number of ecdyses in *Phyllium scythe*, and if this is correct it appears curious there should be such a discrepancy in the number of moults in the Phylliums.

The larvæ moult for the first time when about six weeks old if kept in a mean temperature of 66° F., the succeeding moults following at intervals varying from five to six weeks.

The colour of the newly-hatched larva is, as previously stated, reddish-brown streaked with dull red, but this soon changes and the larva passes through a regular series of colorations from brown to green during the first fortnight. In the first day or two of larval life hardly any change is noticeable excepting the slightly paler colour; but when the insect is a week old a yellowish-green colour is assumed which gives place in about a fortnight to a beautiful pale green on the dorsal and to a rich glossy green on the ventral side. Later, as the larvæ increase in size, their colour becomes more varied and, although green predominates, many shades occur. Some individuals are beautifully marked with different shades of brown and yellow. These colours combined with the positions assumed by the larvæ render them most inconspicuous on the leaves.

Nor is the resemblance to plant-life confined to colour, for the larva has a very peculiar gait which imitates to a remarkable degree the shaking of the leaves rather than the movements of an insect. The larva of the second stadium is about 20 mm. in

length, but apart from size differs little from that of the previous stage. The sexes, so far as I could see, were indistinguishable at this stage.

In the third stadium the external sexual characteristics first make their appearance. The females are somewhat larger than the males, the former being 28 mm. in length, the latter about 26 mm., whilst the flattened expansions of the abdomen are slightly broader in the females than in the males. The future wings of the male, although at present very insignificant, may now be seen in the form of two small processes on the metathorax; these being entirely absent in the females. Further, the legs of the male larvæ are beautifully mottled with irregular patches of brown and yellow, those of the female being generally without these decorative markings. The fourth larval stadium is characterised by increased sexual dimorphism; the male is about 33 mm. in length and 19 mm. in greatest breadth; the antennæ have now increased a little in length, being 3 mm.; and the future tegmina and wings are present in the form of processes about 4 mm. and 2 mm. long respectively. The female is larger and of a somewhat rounder shape; length 35 mm., breadth 19 mm. The femora of the prothoracic legs are of wider proportions than those of the male, whilst the femora of the mesothoracic legs have, in the middle of their posterior lobe, a brownish spot which is seldom present in so decided a form in the male larvæ. The future tegmina may be noticed in the shape of two small processes, about $1\frac{1}{2}$ mm. in length; the antennæ remain short, in contrast to those of the male. The sexual dimorphism becomes gradually more pronounced at each of the succeeding stadia, and reaches its fullest significance in the adult condition. In the penultimate stage the sexes are very dissimilar; the male is about 55 mm. in length, 25 mm. in greatest breadth; has moderately long antennæ; the future tegmina and wings are well defined as two pairs of dorsal appendages, and the expansions of the prothoracic legs are comparatively small. The female is altogether much larger, being about 70 mm. long and 35 mm. broad; has short antennæ; only one pair of dorsal appendages (tegmina), and the foliaceous expansions of the prothoracic legs are very large.

The larvæ throughout their lives are diurnal, but seem to show a decided partiality to feeding during the first and last hours of daylight; food is taken at other times of the day, but a decided preference is shown (at all events in the earlier larval stages) for the twilight. As the sun sinks below the horizon and the light fails the larvæ begin operations by a number of preliminary swinging movements, after which they move in a very hesitating fashion in search of food; having discovered the leaves that are palatable to them, they feed with great avidity for fifteen or twenty minutes. At the end of this time darkness has usually set in and the larvæ once more settle down to await the morning, when the same operations are repeated.

I found that the last larval stadium is frequently prolonged

and lasts eight weeks in many instances. The last week of this stadium is spent in a rather torpid condition during which the larva takes little or no food. A few days before each ecdysis the larva (as in many species of insects) ceases to feed, and having secured a good foothold on the underside of a leaf remains motionless.

After each ecdysis the larva usually devours its cast skin except the legs, and then fasts for about twenty-four hours before recommencing to feed upon the leaves. It takes some time for a moult to be completed, and forty-five or fifty minutes generally elapse from the time of the old skin splitting to the time of the larva being entirely free. The whole process of moulting appears, however, in the Phylliums to be most curious and would take much too long to describe in such an account as the present.

The sexes differ so much in the adult state that they would perhaps hardly be recognised by the uninitiated as belonging to the same species. The males are much more slender and of smaller dimensions than the females, and they do not retain the marvellous leaf-like appearance which characterises the latter. The length of the male varies from 60 to 70 mm. The head is somewhat quadrangular, generally of the same colour as the remainder of the body, and possesses two or three red ocelli which are situated between and slightly behind the level of the bases of the antennæ. The eyes are rather globular and very prominent. The antennæ—which are placed between the eyes—are pilose and very long, often attaining 32 mm.; they are composed of twenty-four joints which are smaller near the head, becoming gradually larger in the middle and finally small again at the extremities. When in motion the insect carries the antennæ forward either in a horizontal or semi-vertical position, but when at rest they are placed backwards as shown in the figure.

The prothorax is heart-shaped and tapers a little toward the posterior end. The mesothorax is broader than the prothorax and carries the tegmina, which are 13 mm. long and of parchment-like consistence. The latter—which only cover a small portion of the wings—are green but frequently spotted with brown or red. The metathorax is of about the same width as the mesothorax and bears two large membranous wings which extend when folded almost to the posterior end of the body. The wings are of delicate texture and are furnished with a regular network of nervures and nervules; in repose they fold up like a fan. They are marked in several places with small dark red streaks.

The first three abdominal segments become successively broader until the maximum width of 24 mm. is reached in the fourth abdominal. At each side of this segment there is a circular transparent spot surrounded by a brown ring, and from here the body becomes gradually narrower, finally terminating in a bifid protuberance. The abdomen is exceedingly flat, and the

laminated expansions are generally pale green on the dorsal and rich emerald-green on the ventral side. The colour, however, varies considerably in different individuals, some being darker green than others, and I have seen one or two quite yellow specimens. The legs with the exception of the prothoracic femora are entirely brown, and being prettily decorated with many shades of yellow look rather like small pieces of decaying leaves. The expansions of the prothoracic femora are of a green and brown colour; they are elegant in shape and, compared with those of the female, are very small.

The females are much larger and more unwieldy creatures than the males. They attain a length of from 95 to 100 mm. The head is large; not quite so quadrangular as in the male and is devoid of the red ocelli. The eyes are much less prominent than in the male, and the antennæ are very short, being composed of only nine segments.

The prothorax takes the form of a shield with a slight furrow in the centre. The mesothorax becomes much broader than the prothorax and bears the remarkable leaf-like tegmina. The latter, which generally remain in a state of repose, are of a most remarkable structure and remind one of leaves to their minutest detail. They are large and ample, being 54 mm. in length, and generally cover the greater part of the abdomen. Each tegmen is similar to half a leaf and has on its internal side a large nervure from which at intervals smaller nervures emanate; these in turn giving off subordinate veins which form a complete ramification throughout the whole structure. The leaf-like form of the tegmina is carried still further since they are adorned with many irregular rust-coloured markings similar to those often found on leaves.

The metathorax is broader than the mesothorax and attains at its posterior end a breadth of 18 mm. The hind wings, which are so conspicuous in the male, are represented in the female by two very small processes, covered by the tegmina and entirely hidden from view.

As in the male, the first three abdominal segments become broader in regular sequence until the maximum width of about 44 mm. is reached in the fourth abdominal segment; from this there is a gradual tapering of the segments to the posterior end which terminates in a bifid protuberance. The abdomen of the female, although possessing flat expansions of considerable size, is very bulky compared with that of the male, and even increases in volume as the ova mature. The general colour of the abdomen is green of varying tints, and it is almost impossible to describe one colour as applicable to all or even to many individuals. Perhaps pale leafy-green is the commonest colour of the dorsal side whilst the ventral is rich emerald-green. St. Quintin says he has "bred some entirely yellow and several of a crushed-strawberry colour, while a few were of an amber-brown."

Similar spots to those which were found on each side of the

fourth abdominal segments of the male occur also in the female, but instead of being transparent they are often opaque and of a brownish-red colour. The first three abdominal segments are generally ornamented at their edges with brown markings, and there is frequently a brown patch at each side of the seventh abdominal segment. Further, there is often an interrupted brown mediodorsal line extending from the sixth abdominal segment to the anal extremity.

The femora of the prothoracic legs are very large and foliaceous, having flat expansions which are green with many brown and yellow markings. The mesothoracic legs are also of moderate size, and on the posterior lobe of each femur there is a large and conspicuous brown spot. All the legs, however, have these laminated expansions to a greater or less degree and the general appearance of a female is that of a leaf.

Becquerel and Brongniart (1894) have carried out spectroscopic investigations on the colouring-matter of the *Phylliums* with a view to ascertaining whether it presented the same optical characters as the chlorophyll of leaves. They found that the spectrum of the *Phylliums* scarcely differs from the spectrum observed through living leaves, but slight distinctions were seen when compared with solutions of chlorophyll.

The majority of the males assumed the imago state long before the females. The first male appeared on March 8th, 1908, and others followed at irregular intervals until May and June, when the maximum number was reached. From this time there was a gradual diminution in the number of males. The first female emerged on May 22nd, 1908. They continued to appear until the end of August. Morton (1903) speaks of his first male as appearing about six weeks before the first female, and says that nearly all the males were dead when this individual appeared. St. Quentin (1907) also notes that his first male emerged one month before the first female. I do not know whether the majority of the males arrive at maturity before the females in the Seychelles, but from the foregoing evidence such a state of affairs seems quite possible.

The males are very active and are quite capable of flying a few yards. Their activity is increased after dark, when they usually move briskly over the leaves and occasionally fly from one bough to another. Being so agile they are rather difficult to handle, and if touched generally drop or take a short flight to some neighbouring object. The females, on the other hand, are very sluggish insects and seldom move far. They are quite unable to fly, and if from any accidental cause they lose their foothold, can only ease the fall by means of their tegmina which spread out like a parachute.

The life of the male is of about four or five weeks duration and food is taken as in the larval stages. The females are much longer lived and survive eight or nine weeks at least; they eat much more than the males and consume in this period an

immense quantity of foliage. The male generally selects his mate during the night, and copulation takes place at some time between 8 a.m. and 3 p.m. the following day. The sexes are united for at least two hours.

I have not been able to ascertain so far the exact number of eggs produced by one individual, but think that from eighty-five to a hundred is the probable number.

Summary.—The Phylliums are dependent upon a very warm and moist atmosphere, and are therefore more or less confined to the islands in the tropical zone: in all stages they are very similar, both in colour and habits, to various plant-structures. Post-embryonic development is slow and takes place by a gradual increase in size of the individual, adults only differing externally from the young larvæ in the possession of fully developed tegmina and wings. The sexual dimorphism is pronounced, the females being large and foliaceous, whilst the males are much smaller and although flat are not characterised by such a leaf-like appearance as the females.

In conclusion, I wish to express my indebtedness to Professor Hickson and Mr. Hewitt for their kind assistance.

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EXPLANATION OF PLATE XXVIII.

Phyllium crurifolium.

The figures represent the adult male and female of the natural size, and were photographed from living examples.

1. Female imago.

2. Male imago.

2. The Mammals of Matabeleland. By E. C. CHUBB, F.Z.S.,
Acting Curator of the Rhodesia Museum.

[Received December 29, 1908.]

The Rhodesia Museum has acquired during the past two years sufficient material to give a good idea of the mammalian fauna of the Western Province of Southern Rhodesia, and it is upon this collection that the present paper is based. For the sake of completeness, however, I have included the mounted examples of big game that were in the Museum prior to this period, and also a few species known to occur in the country, though up to the present unrepresented in the Museum.

The only previous paper dealing with the mammals of this area is that of De Winton *, being a list of a collection made by Selous at Essexvale. The species therein recorded are also incorporated in this list.

Two interesting Bats, *Rhinolophus empusa* and *Clascotis percivali*, are now recorded for the first time from South Africa south of the Zambezi, hitherto being known only from the type localities, Nyasaland and British East Africa respectively.

The probability of the different geological formations supporting distinct vertebrate faunas was pointed out to me some time ago by my former colleague, Mr. F. P. Mennell, and indeed this seems to be borne out in a remarkable way by at least one group among

* P. Z. S. 1896, p. 798.

the mammals, viz. the Elephant-Shrews, one of which, *Elephantulus rupestris myurus*, occurs wherever there is an outcrop of granite, while the other, *Nasilio brachyrhynchus*, is found only on the schists. Although separated generically on dental characters, these two shrews are very closely allied in other respects and are of very similar habits. They are never found living together, however, for whereas the latter is common at Bulawayo on the schist, yet on the granite only two miles west of the town, and also at Helenvale about 15 miles north, and the Matopos some 40 miles south, it is replaced by *Elephantulus rupestris myurus*.

As a general rule the mammals here get their new annual coats at the beginning of the rainy season, about October or November, and the contrast between the old faded coat and the new one is very marked in jackals killed in, say, August and November.

The country slopes down from a line running north-east through Bulawayo, at an altitude of about 4500 feet above the sea, to the Zambezi and Limpopo Rivers on either side, which are about 2000 feet and 1500 feet respectively.

I must express my indebtedness to Mr. Oldfield Thomas, Dr. Knud Andersen, and Mr. R. C. Wroughton, who have been good enough to compare and identify a number of specimens for me.

The native names are those of the Matabele, an offshoot of the great Zulu nation, who trekked up from the south about seventy years ago. The letters "c" and "q" in these names represent clicks. "c" is made by pressing the tongue against the front upper teeth and quickly withdrawing it, as *isance*. It is much the same sound as the expression of vexation "tut." "q" is made by curling the tip of the tongue upwards against the roof of the mouth and quickly withdrawing it, as *iqaga*. This click sounds like the "pop" of a cork when extracted from a bottle.

1. CERCOPITHECUS PYGERYTHRUS Cuv.

There are two flat skins, without skulls, of this Monkey in the collection. One was obtained near Inyati and the other in the Matopo Hills, where the species is fairly common.

Native name : *Inkau*.

2. PAPIO sp.

♂. 17 Oct., 1907. Matopos.

♀. 6 Sept., 1907. „

Native names : *Indwangu* and *Imfene*.

3. GALAGO MOSSAMBICUS Pet.

♂. 9 May, 1908. Bulawayo.

♂. 3 Aug., 1908. „

♂. 19 March, 1908. Gambo's, Manzamnyama River.

Nocturnal. It lives in a thorn-tree (*Acacia horrida*), and sleeps during the day in the hollow trunk or in a roughly

constructed nest of grass and twigs in a fork among the branches. Its food consists chiefly of insects, which it catches with its hands, but the gum of the tree on which it lives is also relished. This it takes in its hands and licks.

Its eyes are a rich dark red or mahogany colour, with a round pupil.

Native names: *Ugwintu* and *Umpugunyoni*.

4. RHINOLOPHUS DARLINGI K. And.

♂ ♀. Mazeppa Mine, Gwanda. In al.

Native name for all Bats: *Uluwane*.

5. RHINOLOPHUS AUGUR ZAMBESIENSIS K. And.

♂ ♀ ♀. 5 April, 1907. Bulawayo.

♂ ♀ ♀. 9 April, 1908. „

3 ♂, ♀. Mazeppa Mine, Gwanda. In al.

Lives in caves in granite kopjes and also in mines.

6. RHINOLOPHUS EMPUSA K. And.

♂. Mazeppa Mine, Gwanda. In al.

This is interesting as being the second known individual example of the species, and also the first record of its occurrence south of the Zambezi. It was described on a specimen from Zomba, Nyasaland*.

7. RHINOLOPHUS HILDEBRANDTI Pet.

♂ ♀. 22 Sept., 1907. Malute Reef, Pandangwe, Gwanda.

4 ♂, 5 ♀. Mazeppa Mine, Gwanda. In al.

Lives in mines.

8. HIPPOSIDERUS CAFFER Sund.

♀. 12 Oct., 1907. Mazeppa Mine, Gwanda.

2 ♂, 4 ♀. Mazeppa Mine, Gwanda. In al.

9. CLÆOTIS PERCIVALI Thos.

♀ imm. Mazeppa Mine, Gwanda. In al.

♂, 2 ♀. 18 Aug., 1908. Mazeppa Mine, Gwanda. In al.

10. NYCTERIS CAPENSIS Smith.

♂. 12 June, 1907. Bulawayo.

♂, 3 ♀. 15 June, 1907. Bulawayo.

♂, 5 ♀. Sept. 1907. Mazeppa Mine, Gwanda. In al.

Four out of the five females in alcohol are pregnant.

11. VESPERTILIO MINUTUS Temm.

♂. 25 June, 1908. Bulawayo.

♂. 5 July, 1908. „

3 ♂, 3 ♀. July, 1908. Bulawayo. In al.

* Ann. Mag. N. H. (7) xiv. p. 378, 1904.

This Bat makes its appearance just after sunset. It flies rather low, and frequents in considerable numbers the neighbourhood of cowsheds for the insects which abound over manure-heaps.

12. *SCOTOPHILUS NIGRITA* Schreb.

♂. 5 June, 1908. Bulawayo.

13. *MINIOPTERUS SCHREIBERSI* Natt.

♂. 1 March, 1907. Bulawayo. In al.

♀. 26 Aug., 1907. „

♀. 17 Aug., 1907. Gravesend Farm, Bembezi River.

This species often flies into houses in the evening.

14. *ELEPHANTULUS RUPESTRIS MYURUS* Thos. & Schw.

♀. 24 Sept., 1907. Syringa.

2 ♂, ♀. 20 April, 1908. Mt. Silozi, Matopos, 4400 ft.

♀. 7 May, 1908. Near Bulawayo.

June, 1908. Helenvale Farm, near Bulawayo. (In alcohol.)

Diurnal. It lives under boulders on granite kopjes or among the heaps of large stones which frequently occur on the granite formation. Its food consists of various kinds of insects—the stomach of one that I found was full of leaf-cutting ants.

Though shy, venturing only with great caution away from its retreat, and returning at the slightest approach of danger, it is also inquisitive, and will sit under the ledge of a rock eyeing one with curiosity and apparent unconcern for its safety.

Average measurements, taken in the flesh, of the three Silozi examples:—Head and body 121 mm.; tail 133; hind foot 35; ear 31; proboscis 14.

Native name: *Utswebe ulukulu*.

15. *NASILIO BRACHYRHYNCHUS* Smith.

♂. 6 Sept., 1907. Bulawayo.

♀. 5 Sept., 1907. „

♀. 31 July, 1908. „

This species appears to be confined to the schist formation, and its colour harmonizes well with the red soil. Like the former species, it lives among heaps of stones. The example killed on 5th September contained one well-developed foetus. Two were shot, while the third was caught in a trap baited with fish.

Average measurements, taken in the flesh, of the three specimens:—Head and body 108 mm.; tail 104; hind foot 29; ear 20.

Native name: *Utswebe ulukulu*.

16. *CROCIDURA* sp.

♀. 20 June, 1908. Bulawayo.

2. Bulawayo. In al.

Native name: *Utswebe*.

17. *FELIS LEO* Linn.

♂. 9 Oct., 1907. Near Eagle Vulture Mine, Gwanda.

The Lion is frequently met with in various parts of the country.
Native names: *Isilwane*, *Impamvu*, *Ingwonyama*.

18. *FELIS PARDUS* Linn.

The Leopard is by no means uncommon in many parts of the country. It lives in the Matopo Hills, and I know of a number having been killed recently at Belingwe.

Native name: *Ingwe*.

19. *FELIS SERVAL* Erxl.

Kahlele's, Matopos.

June, 1908. Gwaai River.

Native name: *Indhlozi*.

20. *FELIS OCREATA* Gmel.

♂. 1 Oct., 1907. Near Bulawayo.

Native name: *Igola*.

21. *FELIS CARACAL* Güld.

18 June, 1906. Near Bulawayo.

Native name: *Intwane*.

22. *CYNÆLURUS JUBATUS* Erxl.

The Cheetah is occasionally killed in the country, and I know of one which was shot recently at Essexvale.

Native name: *Ihlozi*.

23. *VIVERRA CIVETTA* Linn.

♀. June 1907. Kahlele's, nr. Mt. Silozi, Matopos.

Native name: *Isimbaluti*.

24. *GENETTA LUDIA* Thos. & Schw.

16 March, 1908. Bembezi Diamond Fields.

♂. 25 Sept., 1908. Bulawayo.

Native name: *Insimba*.

25. *GENETTA RUBIGINOSA* Puch.

2. Kahlele's, Matopos.

Native name: *Insimba*.

26. *MUNGOS CAFER* Gmel.

A skin without skull; killed at Wankies in September 1908.

Native name: *Uwobo*.

27. *MUNGOS CAUVI* Smith.

♂. 1 July, 1907. Inyamandhlovu.

♀. 17 July, 1907. Bulawayo.

♂. 19 July, 1907. Bulawayo.

♂. 19 Sept., 1907. Syringa.

♂. 23 Sept., 1907. „

Diurnal and common. It may be seen crossing roads or foot-paths at all times during the day.

Native names: *Ubucakidi* and *Uwobo*.

28. MUNGOS ALBICAUDA Cuv.

♂. 4 Sept., 1908. Syringa.

This specimen has a black tail, as is often the case in this species. Said to live in kopjes and to feed on rats and mice. Iris grey.

Native name: *Iduhwa elimnyama*.

29. HELOGALE PARVULA, Sund.

♂ ♀. 28 Oct., 1907. Near Bulawayo.

May 1907. Lukozi River, Wankies Dist.

Diurnal. It lives in colonies among the boulders of granite kopjes, and feeds on insects.

Native name: *Ubutwetwetwe*.

30. CYNICTIS SELOUSI de Wint.

♀. 23 May, 1907. Bulawayo.

♀. 21 June, 1907. „

♀. 11 July, 1907. „

2. 1 July, 1907. Inyamandhlovu.

♀. 5 Aug., 1907. Bulawayo.

♀. 8 Aug., 1907. „

♂. 13 Aug., 1907. „

♀. 27 June, 1908. Near Bulawayo.

Nocturnal and common. It lives in holes in the ground, and feeds on small mammals and birds.

Native name: *Iduhwa*.

31. PROTELES CRISTATUS Sparrm.

A native skin from 16 miles south of Bulawayo.

Native name: *Isance*.

32. HYÆNA CROCUTA Erxl.

♂. June 1908. Gwaai River.

Not uncommon in the forest-belts, known as "gusos," where its white chalky droppings are often seen.

Native name: *Impisi*.

33. CANIS MESOMELAS Ehrenb.

♀ imm. 15 Jan., 1908. Bulawayo.

Common, chiefly nocturnal.

Native name: *Ikanka*.

34. *CANIS ADUSTUS* Sund.

♂. 15 Nov., 1907. Kana River.

Native name: *Igowa*.

35. *OTOCYON MEGALOTIS* Desm.

A head-skin of this species from near Wankies is in the collection.

36. *LYCAON PICTUS* Temm.

♀. 1 Sept., 1907. Sebakwe.

Antelope Mine, S. of Matopos (skull only).

Native name: *Iganyana*.

" 37. *AONYX CAPENSIS* Schinz.

1 Dec., 1907. Belingwe.

Native name: *Intini*.

38. *MELLIVORA RATEL* Sparrm.

Belingwe.

Native name: *Umantswane* and *Ulinda*.

39. *ICTONYX CAPENSIS* Kaup.

3 April, 1907. Bulawayo.

♂ ♀ imm. 8 Nov., 1907. Bulawayo.

♂. 22 May, 1908. Bulawayo.

♂. 16 July, 1908. Near Bulawayo.

Nocturnal, and not uncommon.

Native name: *Iqaqa*.

40. *FUNISCIURUS CEPAPI* Smith.

♂. Sept., 1907. Syringa.

♂. 14 Oct., 1907. Bulawayo.

♂. 1 Dec., 1907. Tokwe River.

♂ ♂ ♀ ♀. 19 April, 1908. Mt. Selozi, Matopos.

This Squirrel has two very different habitats. It lives on granite kopjes and also in the forests of mopane (*Copaifera mopane*).

Native names: *Ubuhlula*, *Isikale*, and *Uwobo*.

41. *GRAPHIURUS PLATYOPS* Thos.

♂. 17 Oct., 1907. Syringa.

♂. 21 Oct., 1907. „

42. *GRAPHIURUS GRISELDA* Schwann.

♀. 1 April, 1908. Bulawayo.

♀. 16 Sept., 1908. „

43. *TATERA LOBENGULÆ* de Wint.*Gerbillus leucogaster* de Wint. P. Z. S. 1896, p. 806.

♂. 10 June, 1907. Springvale Farm.

♀ ♀. 11 Sept., 1907. Bulawayo.

♂. 23 Sept., 1907. Buck's Reef, Gwanda.

♀. 23 Oct., 1907. Khami River.

♀. 16 Nov., 1907. Kana River.

♀. 23 Nov., 1907. Swena's, Gwamayaya River.

Essexvale (*Selous*).

Mammary formula: 2—2 = 8.

Lives in holes in the ground, and is partially diurnal.

Native name: *Imbeba*.44. *OTOMYS IRRORATUS AURATUS* Wr.

♂. 10 June, 1907. Springvale Farm.

Native name for all Rats: *Igundwane*.45. *DENDROMUS MESOMELAS* Brants.

♂. 24 May, 1908. Helenvale Farm, near Bulawayo.

Caught in the nest, which was formed of woven grass-blades and suspended among tall grass about 4 ft. 6 in. from the ground. It appears to be very like the English Harvest-mouse in habits.

46. *MUS NIGRICAUDA* Thos.

♀. 27 April, 1907. Bulawayo.

♀. 7 Oct., 1907. „

♀. 28 May, 1908. „

Crepuscular, nocturnal, and strictly arboreal. It lives in the common thorn-tree (*Acacia horrida*) and feeds upon the gum which exudes from it. The first example was taken alive with four young from a tree that was being cut down.

Mammary formula: 1—2 = 6.

47. *MUS RATTUS* Linn.Essexvale (*Selous*).

Very common in houses near Bulawayo.

48. *MUS CHRYSOPHILUS* de Wint.

♂. 6 April, 1907. Bulawayo.

♂. 12 Oct., 1907. „

♂. 10 June, 1907. Springvale Farm.

♂. 16 Sept., 1907. Syringa.

♀. 22 Sept., 1907. Pandangwe Kopjes, Gwanda.

♂ ♀. 12 Nov., 1907. Indabambi's, Shangani River.

♂ ♀. 24 May, 1908. Helenvale Farm.

Essexvale (*Selous*).

Mammary formula 1—2 = 6. This is our commonest rat. On rough granite country and kopjes it takes grass into the crevices between rocks to form nests. It occasionally enters houses.

49. *MUS AURICOMIS* de Wint.

P. Z. S. 1896, p. 807.

Essexvale (*Selous*).50. *MUS COLONUS* Brants.

3 ♂, ♀. 10 June, 1907. Springvale Farm.

♂. 4 Sept., 1907. Bulawayo.

♂. 18 Sept., 1907. „

♀. 9 Nov., 1907. Shangari River.

♀. 12 Nov., 1907. Indabambi's, Shangani River.

Very common, and enters houses.

51. *MUS MICRODON* Pet.

♀. 16 March, 1907. Bulawayo.

♂. 14 Feb., 1908. „

♀. 8 April, 1908. „

♂. 3 May, 1908. „

♂. 20 April, 1908. Kahlele's, Matopos.

♂. 25 May, 1908. Helenvale Farm.

This like *Mus colonus* often enters houses.52. *MUS MUSCULUS* Linn.

♀. 24 March, 1907. Bulawayo.

Very common.

53. *LEGGADA MINUTOIDES* Smith.

♂. 7 Nov., 1907. Tjokos', Shangani River.

54. *SACCOSTOMUS HILDE* Schwann.

25 Oct., 1907. Khami River,

♂. 7 Feb., 1908. Near Bulawayo.

This species has only been found on the granite formation.

55. *ACOMYS SELOUSI* de Wint.

P. Z. S. 1896, p. 807.

Essexvale (*Selous*).56. *ARVICANTHIS PUMILIO DILECTUS* de Wint.

♂ ♀. 10 June, 1907. Springvale Farm.

57. *ARVICANTHIS DORSALIS* Smith.

♂. 4 Sept., 1907. Bulawayo.

♂. 5 Sept., 1907. „

♀. 18 Sept., 1907. „

♂. 21 Sept., 1907. Buck's Reef, Gwanda.

♂. 18 Oct., 1907. Bulawayo.

Diurnal.

58. GEORYCHUS NIMRODI de Wint.

P. Z. S. 1895, p. 808.

Essexvale (*Selous*).

59. PEDETES CAFER Pall.

♂. 13 June, 1907. Colleen Bawn Mine, Gwanda.

♂. 18 Jan., 1908. Bulawayo.

♀. 14 Oct., 1908. Bulawayo.

Native name: *Myelane*.

60. THRYONOMYS SWINDERIANUS Temm.

♀. 16 Sept., 1907. Bulawayo.

♂ yg. 1 Aug., 1908. „

♂. 9 Oct., 1907. Springvale Farm.

Mammary formula 2—1=6.

Native name: *Ivondo*.

61. HYSTRIX sp.

The Porcupine occurs in the country, but I have not succeeded in obtaining an example of it yet.

Native name: *Inungu*.

62. LEPUS ZULUENSIS MICKLEMI Chubb.

♂. 13 April, 1907. Bulawayo.

♂. 15 April, 1907. „

2 ♀. 4 May, 1907. „

♂. 13 July, 1907. „

♂. 27 April, 1908. „

♂. 2 May, 1908. „

♀. 4 August, 1908. „

1 July, 1907. Nyamandhlovu.

Very common.

Native name: *Umvundhla*.

63. PRONOLAGUS RUDDI RANDENSIS Jameson.

Syringa.

Confined to granite kopjes.

Native name: *Inteletja*.

64. DAMALISCUS LUNATUS Burch.

♂ ♀. Near Mangwe.

Native name: *Inkolome*.

65. CONNOCHÆTES TAURINUS Burch.

♂ ♀. Near Mangwe.

Native name: *Inkonkoni*.

66. CEPHALOPHUS GRIMMI Linn.

♀. Near Mangwe.

♂. 9 July, 1907. Insiza.

3 ♂, 2 ♀. 24 Oct., 1907. Mt. Silozi, Matopos.

♂. Inyati (*albino*).

Native name : *Impunze*.

67. OREOTRAGUS OREOTRAGUS Zimm.

♂, ♀, yg. Near Mangwe.

♂ yg., ♀. 24 Oct., 1908. Mt. Silozi, Matopos.

♀. 17 April, 1908. Near World's View, Matopos.

Native name : *Igogo*.

68. RAPHCERUS CAMPESTRIS Thun.

♂ ♀. Near Mangwe.

♀. 4 June, 1907. Springvale Farm, near Bulawayo.

♂. 25 Oct., 1907. Mt. Silozi, Matopos.

Native name : *Inqina*.

69. RAPHCERUS SHARPEI Thos.

♂. Aug., 1908. Near Inyati.

♂. Oct., 1908. Sinonombi.

Native names : *Isanempa* and *Isanhlunywana*

70. KOBUS ELLIPSIPRYMNUS Ogilby.

♀. Near Mangwe.

♂. Oct., 1908 (head only). Sinonombi.

Native name : *Isidumuka*.

71. CERVICAPRA ARUNDINUM Bodd.

♂ ♀. 24 Oct., 1907. Mt. Silozi, Matopos.

Native name : *Umzigi*.

72. ÆPYCEROS MELAMPUS Licht.

2 ♂. Oct., 1908. Sinonombi.

Native name : *Impala*.

73. HIPPOTRAGUS EQUINUS Desm.

♂ ♀. Near Mangwe.

Native name : *Itaga*.

74. HIPPOTRAGUS NIGER Harris.

♂ ♀. Near Mangwe.

Native names : *Umtjwayili* and *Ingwalati*.

75. STREPSICEROS STREPSICEROS Pall.

♂ ♀. Near Mangwe.

Native name: *Imbalabala*.

76. TAUROTRAGUS ORYX Pall.

♂ ♀. Aug., 1907. Kana River (skeletons).

Native name: *Impofu*.

77. BUBALUS CAFFER Sparrm.

The Buffalo is found in Northern Matabeleland, and I know of two males being shot there in October 1908.

Native name: *Inyati*.

78. GIRAFFA CAPENSIS Less.

♀. Near Mangwe.

Native name: *Intudhla*.

79. HIPPOPOTAMUS AMPHIBIUS Linn.

There are many hippos still in the country, and some were shot at Belingwe this year.

Native name: *Imvubu*.

80. POTAMOCHÆRUS CHÆROPOTAMUS Ill.

♂. July 1908. Matopos.

Native name: *Ingulugundu*.

81. PHACOCHÆRUS ÆTHIOPICUS Pall.

♂. Oct. 1907. Khami R.

Fairly common all over the country.

Native name: *Ingulubi*.

82. EQUUS BURCHELLI CHAPMANI Layard.

2. Near Mangwe.

Native name: *Idube*.

83. DICEROS BICORNIS Gmel.

♂. Jan., 1907. Gwelo.

Native name: *Umkombo*.

84. PROCAVIA CAPENSIS Pall.

♂ imm. 13 Sept., 1907. Syringa.

♂ ♀. 23 Sept., 1907. Pandangwe Kopjes, Gwanda.

2. 20 Feb., 1908. Between Lochard Siding and Inyati.

♂. 17 April, 1908. Near World's View, Matopos.

♂. 19 April, 1908. Mt. Silozi, Matopos.

One of the skins from between Lochard Siding and Inyati has a large white patch on the top of the head.

Native name: *Imbila*.

85. *PROCAVIA BRUCEI* Gray.

♂. 24 April, 1908. Kahlele's, Matopos.

Trapped in tree by natives.

Native name: *Imbila*.

86. *ELEPHAS AFRICANUS* Blum.

The Elephant is to be found in Northern Matabeleland, and I saw fresh spoor of a herd on the Kana River in November, 1907.

Native names: *Indhlovu* and *Inkubu*.

87. *MANIS TEMMINCKI* Smuts.

♂. 22 April, 1907. Wankies.

Native name: *Inkaka*.

88. *ORYCTEROPUS AFER* Pall.

♂. Aug., 1907. Mapisa's, near Figtree.

♀. 24 Oct., 1908. Shiloh.

Native names: *Isambane* and *Iwombela*.

3. Report on Deaths which occurred in the Zoological Gardens during 1908. By H. G. PLIMMER, F.L.S., F.Z.S., Pathologist to the Society.

[Received February 1, 1909.]

On January 1, 1908, the number of animals in the Zoological Gardens was 3190 and during the year there were 2418 new arrivals, making a total for the year of 5608. 1737 animals have died during the year, that is roughly 31 per cent., but if from this number we subtract 769 animals which did not live for six months after their arrival in the Gardens—that is, those which had not got used to their new environment—the percentage of deaths is reduced to 17 per cent., which is probably a much fairer number to take.

Of those which have died, 1089 have been examined, and in 41 of these no cause of death could be found. Of the remainder 129 died from injuries of various sorts, or were lost, or not sent for examination, and 30 died from exhaustion due probably to depressed vitality from cold or darkness, or from inability to get or to take food.

The Tables which follow show the facts ascertained in bare outline, and following them are some short notes on the most important points connected with these facts.

Table I. sets forth the causes of death in each of the three great classes of animals. Under Reptiles are included batrachians and fishes.

TABLE I.—Analysis of 993 deaths.

DISEASE.	MAMMALS.	BIRDS.	REPTILES.	
1. <i>Microbic or Parasitic Diseases.</i>				<i>See Notes.</i>
Tuberculosis	59	88	17	1.
Mycosis .....	.....	55	.....	2.
Malaria .....	.....	14	.....	3.
Filaria	3	18	1	4.
Trypanosomiasis	1	2	.....	5.
Hamogregarines .....	.....	.....	24	6.
Pneumonia	47	29	19	7.
Septicæmia	12	1	.....
Pseudo-tuberculosis	3	.....	.....
Hydatids	1	.....	.....
Worms	3	.....	15	
Itch.....	3	.....	.....
Protozoal infection .....	.....	.....	1	8.
2. <i>Diseases of Lungs.</i>				
Broncho-pneumonia	44	.....	.....
Congestion of lungs	29	100	14	9.
3. <i>Diseases of Heart.</i>				
Pericarditis	7	3	1	
Fatty degeneration .....	.....	3	.....
4. <i>Diseases of Liver.</i>				
Hepatitis	2	.....	.....
Fatty degeneration	1	13	3	
5. <i>Diseases of Alimentary Tract.</i>				
Stomatitis	1	2	.....
Gastritis	4	1	2	
Gastric ulcer	11	1	1	10.
Gastro-enteritis	23	2	27	} 11.
Enteritis.....	57	139	31	
Colitis	15	.....	1	
Acute tympanites	1	.....	.....
Intussusception.....	1	.....	.....
Obstruction .....	.....	1	.....
Peritonitis	15	2	.....
6. <i>Diseases of the Urinary and Reproductive Organs.</i>				
Nephritis	4	1	.....
Inflammation of oviduct .....	.....	2	1	
7. <i>Various.</i>				
Senile changes	1	.....	.....
Anæmia without ascertainable cause	5	2	3	12

Table II. shows the distribution of these diseases amongst the principal classes of Mammals.

TABLE II. -Distribution of diseases amongst the Mammals.

<i>Disease.</i>	<i>Primates.</i>	<i>Carnivora.</i>	<i>Rodentia.</i>	<i>Ungulata.</i>	<i>Edentata.</i>	<i>Marsupialia.</i>
Tuberculosis.....	35	3	14	2	...	5
Filaria	3	...	...	...	...	...
Trypanosomiasis .....	...	...	1	...	...	...
Pneumonia	9	10	14	6	2	6
Septicæmia	2	5	...	4	...	1
Pseudo-tuberculosis .....	...	...	3	...	...	...
Hydatids	1	...	...	...	...	...
Worms	1	2	...	...	...	...
Itch .....	...	...	2	1	...	...
Broncho-pneumonia	17	5	3	10	2	7
Congestion of lungs	13	5	5	3	...	3
Pericarditis	1	3	...	2	...	1
Hepatitis .....	...	1	1	...	...	...
Fatty degeneration of liver .....	...	...	1	...	...	...
Stomatitis	1	...	...	...	...	...
Gastritis .....	...	1	1	1	...	1
Gastric ulcer	3	2	2	...	...	4
Gastro-enteritis	2	8	3	3	...	7
Enteritis	12	11	9	13	2	10
Colitis	8	3	...	2	...	2
Acute tympanites .....	...	...	...	...	...	1
Intussusception .....	...	...	...	...	...	1
Peritonitis	1	1	3	7	...	3
Nephritis	2	2	...	...	...	...
Senile changes .....	...	...	...	1	...	...
Anæmia (cause unknown) .....	...	1	1	...	1	2

Since the lesions of tuberculosis and mycosis are somewhat similar in appearance, care has been taken to separate them accurately, and the following Table sets forth their distribution amongst the different classes of birds.

TABLE III.—Comparative Table of the incidence of Tuberculosis and Mycosis in the various classes of birds.

	<i>Tuberculosis.</i>	<i>Mycosis.</i>
Passeres	34	9
Picariæ	2	5
Psittaci	2	11
Anseres	4	8
Columbæ	12	3
Gallinæ	29	9
Striges	2	5
Laridæ	1	5
Struthionæ	2	...

The seasonal variations of the principal diseases are very much as might be expected, and there seems to be little of importance to record in this connection. Tubercle remains pretty constant all the year round; mycosis has been more prevalent during the second and fourth quarters; pneumonia and broncho-pneumonia were more prevalent during the first and fourth quarters; and diseases of the alimentary canal have been more marked in the latter half of the year.

There has fortunately been no epidemic amongst the animals during the year, and disinfection has been carried out after every case of infectious disease, so as to lessen, as far as possible, the risks of infection. It will be noticed that there has not been a single case of tumour, cancerous or otherwise, in the animals examined during the year.

Notes on the foregoing Tables.

The following notes refer to a few points of special interest in connection with the diseases mentioned in the Tables.

1. Since the beginning of last year all reptiles have been systematically examined, and tubercle has been found in 17 cases out of a total of 161; and in 5 snakes, tubercular deposits have been found in the lungs. Pulmonary tubercle in reptiles has not, I believe, been described before, and the first specimen found has been preserved in the Museum of the College of Surgeons. Tubercle found in reptiles has so far been all of the avian type, both microscopically and in cultures.

The 88 cases of tubercle in birds seems a large number, but it compares favourably with the number of cases recorded* as occurring in the Berlin Zoological Gardens between December 1903 and August 1905. Between these dates 459 birds were examined there, of which 118 were tuberculous; our figures show that of 479 birds examined only 88 were tuberculous. In two parrots examined the tubercle was of the human type, in all the rest it was distinctly avian.

Of the 35 cases of tubercle in monkeys nearly all were of the human variety, two, however, were of a distinctly bovine type, and in one case the bacilli were of the avian type.

2. In four of the cases of mycosis the disease was due to *Aspergillus niger*, the lesions being similar to those produced by the *Aspergillus fumigatus* which was the organism associated with the remaining 51 cases.

3. Under the general term Malaria I have grouped a series of cases which, so far as I am at present able to state, are caused by parasites belonging to either the group of *Halteridium* or of *Proteosoma*. In these birds the parasites were certainly the cause of death, but they were also found in 12 other birds which died from other causes.

4. Several of the filaria found have not been described before and are still under investigation. In some cases two quite different kinds of filaria have been found in the same host, as in

* Virchow's Archiv, vol. 90.

two Lawes' Birds of Paradise. The difficulty of identification is much increased by the fact that the parent worms often cannot be found. The filaria found in a Bearded Lizard is, I believe, the first found in a reptile.

5. A hitherto undescribed trypanosome has been found in a Francolin which died from mycosis, which is larger than any described so far in birds.

6. *Hæmogregarines* have been found in 40 reptiles, and in 13 of these, I believe, for the first time. In the cases in which death has been attributed to them the anæmia and blood destruction have been so extreme as to make the diagnosis quite certain; sometimes 50 or even 60 per cent. of the erythrocytes have been affected.

7. Pneumonia in reptiles is of two kinds—one a specific inflammation of the lung, the other a traumatic inflammation due to the irritation produced by ascaris eggs and embryos deposited there. In some cases masses like tubercles are formed around the source of irritation. 13 of these cases were of this irritative kind.

8. This protozoal infection occurred in a bull-frog, and the lesions were identical with those described by Danielewsky in 1889 in his account of the only other case on record in an edible frog. The causative organism which was present in the blood and the exudations in this case was a *Hexamitus* (really *Octomitus*).

9. Of the 29 mammals which died from congestion of lungs, 22 were suffering from rickets, 9 very severely.

10. It will be seen that gastric ulceration is more widely distributed amongst mammals than is usually thought to be the case.

11. The large number of cases of enteritis has led to an investigation into the probable causes. There appear to be three different kinds of enteritis in the Gardens—one which is caused by bacteria, one which is caused by protozoal organisms, and a third variety probably due to errors in feeding. An effort is being made to separate the various kinds, so that at any rate those due to feeding may be got rid of. The very large percentage of cases of gastro-enteritis in the reptiles will be noticed; in 58 out of 161 cases death was due directly to this condition, and in the remainder, which died of other diseases, the same condition was present in varying degrees. It would seem worth while to consider whether the present unnatural and unphysiological method of feeding the snakes has any connection with the very large incidence of inflammations of the alimentary tract occurring in them.

12. In these 10 cases there was very profound anæmia, with considerable blood changes. I think that these cases were in all probability parasitic in origin, but no cause, parasitic or other, could be found.

Several probably undescribed intestinal worms have been found during the year, and are still undergoing investigation.

The work condensed in this paper has been carried out in the laboratories at the Gardens and at the Lister Institute.

February 16th, 1909.

FREDERICK GILLET, Esq., Vice-President,
in the Chair.

The Secretary read the following report on the additions made to the Society's Menagerie during the month of January, 1909 :—

The number of registered additions to the Society's Menagerie during the month of January was 79. Of these 54 were acquired by presentation, 20 by purchase, 2 were received on deposit, and 3 were born in the Gardens,

The number of departures during the same period, by death and removals, was 158.

Amongst the additions special attention may be directed to :—

One Desert Fox (*Vulpes leucopus*) and two Gmelin's Sheep (*Ovis orientalis*) ♂ ♀, the latter new to the Collection, from Persia, presented by Capt. T. H. Keyes, F.Z.S., on Jan. 5th.

One Markhoor (*Capra falconeri*) ♂, from N.W. India, presented by Lt.-Col. S. H. Godfrey, C.I.E., on Jan. 18th.

One Red-cheeked Scimitar Babbler (*Pomatorhinus erythrogenys*) and two Occipital Blue Pies (*Urocissa occipitalis*), from India, purchased on Jan. 21st.

One Javan Drongo (*Crypsirhina varians*), from Java; one Dumont's Grackle (*Mino dumonti*), from the Aru Islands; two Black-throated Lorikeets (*Trichoglossus nigritularis*), two Green-naped Lorikeets (*Trichoglossus cyanogrammus*), and three Green-winged Parakeets (*Aprosmictus chloropterus*), from New Guinea—the Drongo, the Black-throated Lorikeets, and the Green-winged Parakeets being new to the Collection,—purchased on Jan. 18th.

Four Black-cheeked Love-birds (*Agapornis nigrigenis*), from N.W. Rhodesia, new to the Collection, purchased on Jan. 15th and 16th.

Mr. C. Tate Regan, M.A., F.Z.S., exhibited sketches illustrating changes in coloration of some Fishes in the New York Aquarium, and made the following remarks :—

“In September 1907, I paid several visits to the New York Aquarium; the director, Mr. C. H. Townsend, very kindly spent a good deal of time in showing me the fishes and calling my attention to many interesting details. I was particularly struck by the colour-changes in some of the tropical Sea-Perches from the Bermudas, and I made some notes on the coloration of four species, viz. :—

“1. *Epinephelus striatus*.—I devoted some hours in all to the study of this species. The normal coloration, if such a term can be used, may be described thus: ground-colour greyish-olive with irregular paler spots; body crossed by about five broad dark brownish bars; a black spot on the upper part of the bar which

encircles the caudal peduncle. This description would probably apply to some, and usually to most of the specimens observed at any given time, but they were constantly changing, and I came to the conclusion that there must be several different systems which could work independently, either in harmony with or in opposition to each other. These systems were (1) the ground-colour except (2) the pale spots; (3) the upper and (4) the lower halves of the cross-bars and (5) the caudal spot. If these systems worked in harmony the fish would be uniformly coloured, varying from almost white through various shades of greyish-olive and brownish to black. Working independently, the cross-bars might become defined and become even quite black while the ground-colour, remained nearly white, or if the ground-colour became darker the pale spots might or might not appear. The caudal spot was often fading out and suddenly reappearing. Certain changes could only take place in a definite order; the lower halves of the cross-bars never appeared before or persisted later than the upper halves; the caudal spot was never paler than the bar on which it was placed, although it could entirely disappear if the bar had faded out; similarly the bars were never paler than the ground-colour, and although the pale spots could become quite black with the rest of the ground-colour, they could not darken independently of it. All the changes mentioned above could take place either slowly or very rapidly.

"2. *Bodianus punctatus*.—So recently as 1902 Prof. Evermann* distinguished between *B. fulvus*, with the ground-colour lemon-yellow, *B. ruber*, with the ground-colour bright scarlet, and *B. punctatus*, with the ground-colour brownish or blackish-olive. He wrote that these had usually been regarded as subspecies, but that until the fact of intergradation was established, it was best to treat them as distinct species. Individual specimens in the New York Aquarium are continually changing from one so-called species into another. In this species three distinct colour areas, viz. the upper, middle, and lower parts of the fish, separated by straight longitudinal lines, may be recognised. I observed a uniformly yellow fish suddenly assume an orange tint on the back; this gradually deepened into a brownish-red whilst the sides and lower parts became paler. A dark greenish fish changed suddenly into a red fish, and a uniformly red fish became pale on the sides, the upper and lower parts remaining unchanged. A fish with the back chocolate-coloured became darker above and paler below, so that the nearly black back was sharply defined from the almost white sides and lower parts.

"3. *Mycteroperca bowersi*.—A beautiful fish of a brilliant red or crimson, with black edges to the fins. I was only able to watch this species for a few minutes, but saw one red fish become pale pink and another dark olive-green; another in the tank was brownish, and in one the black edges of the fins had disappeared.

* Bull. U.S. Fish. Comm. xx. pt. 1, pp. 149-150.

"4. *Hæmulon flavolineatum*.—Ground-colour changing from pale yellow to deep bronze, with numerous undulating stripes of a blue of varying intensity. Two blackish longitudinal stripes, the lower ending in a spot at the base of the caudal fin, suddenly appeared and disappeared. Similarly, a few irregular broad blackish cross-bars could be turned on and off."

Mr. E. G. B. Meade-Waldo, F.Z.S., read extracts from a letter he had received from Dr. Einar Lönnberg, C.M.Z.S., on the hunting of the Sea-Elephant on South Georgia, and called attention to the necessity of steps being taken to prevent its extermination.

The following papers were read :—

1. The Fauna of the Cocos-Keeling Atoll, collected by F. Wood Jones. By F. WOOD JONES, B.Sc., F.Z.S., with the assistance of other Authors.

[Received December 3, 1908.]

(Text-figures 7-9.)

The fauna of the Cocos-Keeling group has been several times investigated, but it has never been thoroughly worked out. The species enumerated in the following lists were collected during a stay of fifteen months in 1905 and 1906, and the collection, of most orders, may fairly be considered as complete.

Darwin visited the group in 1836 and stayed for only ten days, from April the 2nd to the 12th. Wallace in his 'Island Life' quotes Darwin's list of the fauna (p. 275).

Dr. H. O. Forbes visited the islands in 1879, arriving on January 18th, and staying till February 9th, and he amplified considerably the list made by Darwin; unfortunately his collections were lost in returning to Java, and so the additional species that he observed have not been specifically recorded ('A Naturalist's Wanderings in the Eastern Archipelago,' 1885).

On the 20th of August 1885, Mr. W. E. Birch, on behalf of the Straits Government, landed and made inquiries about the islands and their inhabitants; with him, as naturalist, went the Rev. E. C. Spicer. The expedition visited most of the islets, and remained for eight days in the atoll, but in the report (Straits Blue Book 1885) no light is thrown on the condition of the fauna.

In succeeding Blue Books are scattered notes, made by the Commissioners, on some of the most striking features of the atoll fauna, but most of this information is mere interpretation of local legend, and is of no value.

Dr. H. B. Guppy came to the islands in 1888, and has written

an excellent account of their physical features in the Scottish Geographical Magazine (vol. v. 1889, pp. 281, 457 and 569), but he has not, so far as I am aware, published any description of the fauna.

Since the atoll lies 12 degrees south of the Equator, it is of necessity subjected to some seasonal variations, and though these are greatly moderated by the influence of the South-East trade winds, they are sufficiently pronounced to affect the time of appearance of most of the insect fauna. It is therefore obvious, that a stay of a few days could not produce, even with the most industrious collecting, at all a representative series of the insect fauna. The present list need not therefore be taken as indicating that a great increase has taken place in the fauna within the past thirty years, for it is more properly an index of more protracted collecting at all seasons of the year's cycle.

The atoll consists of some two dozen typical "low" islands, that rise but a few feet above mean tide-level, and enclose a lagoon some 8 miles in diameter. The whole group lies at 12° 10' S., 96° 52' E.; and is separated by upwards of six hundred miles from Java, and upwards of five hundred from Christmas Island, its nearest neighbour.

In 1827 the atoll was settled by the pioneer member of the Clunies-Ross family, and ever since that time the destinies of the group have been swayed by three generations of the same family. The islands were uninhabited before the advent of the Clunies-Ross dynasty. In 1901 a Telegraph-station was erected on Pulu tikus, for the working of the cable between Perth (Australia) and Mauritius.

The South-East trades blow for some three hundred days each year, and the climate is subject to no sudden changes save infrequent cyclones; the mean temperature is 81° Fahr., and the annual rainfall averages something over 70 inches.

MAMMALIA.

The Rats of the atoll are of some interest, apart from their economical importance. When the original settlers arrived in the group in 1827, rats were already established on one of the islands, and this island was named Pulu tikus, or rat island, in consequence.

From 1827 till 1878 these rats remained as the only representatives of their family, and continued to be almost confined to the island of their settlement. Towards the end of 1878 a ship, 'The Robert Portner,' was wrecked in the atoll, and left as her legacy a flourishing colony of *Mus decumanus*; since then other wrecks, and trade intercourse, have added *Mus rattus* to the island fauna. The products of these separate invasions have remained distinct until to-day, and they have fairly sharply defined areas of distribution. The "original rat," as it is called, remains confined to Pulu tikus. *Mus decumanus* is most abundant on

Pulu Selma, and some of the smaller islands to the south. *Mus rattus* has its stronghold on Pulu gangsa, where it is very abundant, but it also occurs on the other islands in company with *M. decumanus*. When Dr. H. O. Forbes visited the atoll in 1879, he noted the great number of rats—these were the ‘Robert Portner rats’ that had invaded the islands in the previous year, and had multiplied to an extraordinary extent. He makes no note of the black rats, and does not mention the race of ‘original rats’ on Pulu tikus.

During Darwin’s visit the only rat in the islands was this Pulu tikus race, and of it he says:—“These rats are considered by Mr. Waterhouse as identical with the English kind, but they are smaller and more brightly coloured” (‘Naturalist’s Voyage,’ p. 461); and Wallace (‘Island Life,’ p. 275) adds, “We have here an illustration of how soon a difference of race is established under a constant and uniform difference of conditions.”

In the seventy years that have passed since Mr. Waterhouse described the rat, the difference appears to have become more marked, and a description of the race is justified for the reason that the modern introduction of rat virus into the atoll may easily exterminate it.

External appearance.—The rat is a slenderly built and sleek looking animal; its general colour is a warm russet-brown. The fur of the back is coarser, and some hairs stand out that are almost black, and are 30 mm. in length; these long dark hairs are more numerous over the hind end of the body than over the shoulders. The general colour of the body is a rather rich brown, the belly being but little lighter than the back in most specimens. The shorter hairs are grey at the base and bright red-brown at the tips; the longer hairs are dark brown to black. The fore limbs are somewhat lighter than the rest of the body, but the hind limbs are of the general rich red-brown. The under surface is only slightly lighter than the back, and is a light warm brown, not grey; the chin and throat are somewhat lighter. The under surface of the scrotum of the male is covered with long bright red-brown hairs, brighter than those of any other part of the body; the distal extremity of the scrotum is bald, the naked skin being a dark purplish brown.

The vibrissæ—many of them more than 60 mm. long—are numerous and dark-coloured. The ears are almost naked, they are oval and prominent and average 22 by 15 mm. The hind feet are large and long, their soles are dark, almost purple, coloured; the digits are slender, the claws are long and much curved. The tail very slightly exceeds the length of the head and body, it is darker than the body colour; it is finely scaled, 12 rows to the centimetre, and sprinkled with numerous fine black hairs. There are two pairs of pectoral mammae, and three inguinal pairs, 2-3=10. The tibiae are almost straight, having practically no “bow” forwards.

The Skull.—The skull is long and narrow, and is delicately

built. The nasals extend posteriorly to the anterior margin of the orbit, are 15.5 mm. long, and 2.8 mm. wide at their broadest part. Basal length of skull 35-38 mm.; greatest breadth 18 mm. Interorbital constriction, least breadth 6 mm. Interparietal, length 5 mm., breadth 10 mm. Length of base of anterior root of zygoma 6 mm. Palate, length 20 mm.; breadth, outside m^1 9 mm., inside m^1 4 mm. Palatine foramina 8 mm., *extending 1 mm. behind the anterior edge of m^1* —this is a constant feature. Alveoli (back of incisors to m^1) 12 mm. Upper molar series 6.5 mm. Incisors pale yellow in the lower jaw, orange in the upper jaw.

The measurements in millimetres of a series of specimens are as follows:—

	Head and Body.	Tail.	Hind foot.	Leg (tibia).	Front foot.	Forearm.	Sex.
1...	190	190	40	50	20	35	♂
2...	207	208	40	45	20	33	♂
3...	195	200	40	50	20	30	♂
4...	195	191	38	42	22	25	♂
5...	205	215	40	52	19	34	♂
6...	187	185	40	50	18	32	♂
7...	192	215	40	50	19	34	♂
8...	200	205	40	45	20	30	♂
9...	180	185	40	45	20	30	♂
10...	163	158	39	40	22	29	♂
11...	150	155	38	39	22	27	♂
12...	147	149	36	38	18	24	♂
13...	215	230	42	45	22	36	♂
14...	198	202	39	48	20	32	♂
15...	187	190	39	48	18	32	♂
16...	170	160	35	42	20	38	♂
17...	120	130	35	35	17	32	♂

Habits.—The rat is very abundant on Pulu tikus, and although it has been steadily trapped, and hunted by dogs, for the last four years, it does not appear to diminish in numbers. As many as forty will still be taken in wire traps beneath the Telegraph quarters in a night, and outside the little area of the station the rat swarms everywhere. It is by no means a house rat, and although it is common in and around the houses it is still more abundant in the outlying parts of the island. It is splendidly adapted to its environment; it has altogether given up burrowing, and it lives in the piles of coconut husks and in the crowns of the palms. It is certain that, at times, the young are born at the tops of the palms, which are 60 to 70 feet high. The rats ascend the trees with the greatest ease, and they run from one palm to the next, across the interlacing fronds, very much after the fashion of the squirrel. They are by no means strictly nocturnal, doubtless from their long freedom from any enemies, and they are to be seen running about at all times of the day. They feed almost entirely upon the fallen coconuts, and all the nuts that I have ever seen opened

have been gnawed by rats, and not torn open by *Birgus latro*, as they are often said to be. Even those that are trapped around the Telegraph quarters are almost invariably full of coconut, and most come into the houses to obtain water rather than for food. Before the Telegraph-station was built no water was available, save that collected during showers in the bases of the palm-leaves. It has been killed in vast numbers since the opening of the Telegraph-station on Pulu tikus in 1901, but its numbers do not seem to have diminished at all. Considering its extreme abundance it does very little harm, save eating the copra stored on the island, and it has never adopted the practice of nibbling the green nut, that makes the rats on the other islands such an economical curse.

Mus decumanus, typ.—This is the pest of the atoll, and does incalculable damage to the coconut plantations. A perpetual war is waged against it by means of traps and dogs; natives are specially told off for the purpose of rat killing, and all the dead rats are regularly recorded. Apart from eating copra, and damaging stores, it has learned to climb the palms, and destroys countless nuts by nibbling them through, just where the stalk joins the husk. It is known in the islands as the 'New' or 'Norwegian' rat, and is always distinguished by the natives from the Pulu tikus rat.

Mus rattus, typ.—Is common on Pulu gangsa and some of the small southern islets, and I have had one specimen from Pulu Selma, where it is not nearly so common as *M. decumanus*. It does not exist in such numbers as does *M. decumanus*, but it has learned the same destructive habits. It is never met with on Pulu tikus.

Mus musculus Linn.—By no means abundant, although for a few months in 1905 it became very common in Pulu tikus; on that island it does not appear to have been seen in any numbers until about 1903, and it was doubtless introduced with stores from Singapore.

A herd of feral deer lived for long in Pulu luar. The animals were introduced from Java and from Singapore, and consisted of two species, the Sambar (*Cervus hippelaphus*) and the Kedang (*Cervus muntjac*). All were dead when I left the islands in 1906, and the only trace of their presence was a well-marked "browse limit" to the trees, a novel feature in a coral-island landscape.

Waifs and strays include bats of some small species that did not appear during my stay in the atoll, and that are said to be the *Pipistrellus murrayi* Andrews, from Christmas Island. A large monkey is also said to have been washed ashore, and to have long survived in the islands; the method of its advent is not known.

The domesticated animals include dogs, cats, and pigs; sheep have been turned down, with but little success; and rabbits liberated on Pulu luar do not seem to have multiplied greatly.

AVES.

COLUBRIFORMES.

(1) CARPOPHAGA WHARTONI Sharpe.

Native name, "Pergám."

Introduced from Christmas Island, but now (1906) practically extinct in the atoll.

RALLIFORMES.

(2) RALLUS PHILIPPENSIS Linn.

Native name, "Ayam utan."

Very abundant on all the islands, and is everywhere very tame, it being a matter of some difficulty to make it take wing. It feeds on the shore when the tide is out, but it may also be seen perched high in papia trees eating the ripe fruit, and it has a bad name for eating the eggs of domestic fowls. It nests in September, in tufts of grass, about a foot from the ground; it lays from two to six eggs, very like the English Cuckoo's. The young are all black when hatched, and can run directly they are out of the egg. The call-note is a shrill grating sound, and in the breeding-season the cock adds a deep croak not unlike the noise made by frogs. This species is not found in Christmas Island.

LARIFORMES.

(3) STERNA FULIGINOSA Gmel.

Native name, "Burung dali."

Breeds in Keeling Island but not in very great numbers. It keeps very much to itself on the breeding grounds, and lays one egg in the sand above the beach rise, on the western side of the island. By sailors it is called the whale-bird. Although not uncommon, and often seen at sea, far from the atoll, it does not occur on Christmas Island.

(4) ANOUS STOLIDUS Linn.

Native name, "Burung krok."

Not resident in the Southern atoll, but a frequent visitor to the lagoon. In Keeling atoll it breeds in great numbers. In June the breeding-season has almost come to an end. The nests are made about a foot above the ground, on little collections of sea-tossed wrack. In the atoll all the "noddies" build close together in a rather limited area. Only one egg was found in each nest.

(5) GYGIS CANDIDA Wagler, Isis, 1832, p. 1223.

Native name, "Burung chuit-chuit" (onomatopoeic).

Darwin noted the bird in 1836 ('Naturalist's Voyage,' p. 462), and H. O. Forbes gave an account of it in 1879 ('Naturalist's Wanderings,' p. 34). The bird agrees with the description of

Wagler :—"Irides nigro-cœruleæ; rostrum nigrum, basi cœruleum; lingua sublata rostro brevior; pedes cœrulei, palma alba, ungues nigri."

In a good description of this bird (Cassin, U. S. Explor. Exped. p. 389) the feet are said to be "pale blue, having a deeply indented yellow membrane." In Gould's 'Birds of Australia,' vol. vii., the feet are described as orange, and are figured of that colour in the accompanying plate. In other accounts it is stated that the feet are yellow or brown. The bird, as I have seen it in the Cocos-Keeling group, invariably has the feet entirely blue, the web being slightly lighter than the toes.

Text-fig. 7.



Egg of *Gygis candida*, laid on the branch of a grongong tree (*Cordia subcordata*).

The bird is a common one, and occurs in all the islands. It breeds in the Southern group as well as in Keeling Island.

Although the bird feeds mostly on fish, it may often be seen hovering around the papaia-trees and eating the soft fruit. It is quite arboreal in its habits, and its one egg is laid sometimes at a height of 40 feet from the ground. Most of the eggs were found in September, but on visiting Keeling Island in June two eggs were found after very little searching. The egg is almost perfectly oval (40-43 mm. in its long axis, 21-22 mm. in its short axis); it is

cream-coloured, mottled and streaked with olive-brown. It is laid on the branch of a tree (*Pisonia inermis*, *Cordia subcordata*, *Guettarda speciosa*) wherever a slight irregularity in the bark suffices to hold it steady (see text-fig. 7). In all the cases that I have seen the egg was laid in the long axis of the branch, and the parent bird sits across the branch in the process of incubation. From the fact that three nesting sites were used twice over, it would seem as though the suitable branches for balancing the egg were somewhat limited. The birds take it in turn to sit, or rather stand, on the egg, and they invariably leave it by falling backwards

Text-fig. 8.



Gygis candida sitting on its egg.

This is the same egg as is shown in text-fig. 7.

off the branch, in order not to disturb it with their feet; great caution is taken in getting into position on the egg again (see text-fig. 8). Incubation lasts 36 days; the newly hatched young is buff-brown, and it does not move from the tree until it has assumed its white feathers. A bird hatched on Sept. 3rd, 1905, did not move from the site of its hatching till Oct. 22nd; it then moved higher up the branch, and remained, with slight changes of position, till Nov. 12th, when it took its first flight (see text-fig. 9, p. 142). Many eggs were watched and in no case did any accident befall them, but a young bird, hatched on Nov. 17th, fell from its insecure

position on the fourth day, and was killed. This bird does not occur on Christmas Island, and is not seen far from the atoll—it is, in fact, a sign that the atoll is near when one is seen on the voyage from Java.

ARDEIFORMES.

(6) *DEMIEGRETTA SACRA* Sharpe.

Native name, "Blakok."

Exists in fair numbers, especially in Pulu atas, where as many as twenty may be seen fishing together. Birds in the white phase and in the grey phase mix freely together; though it is said in the islands that white pair with white, and grey with grey. The nest is made in the Pisonia trees, and two pale blue eggs are laid. I obtained specimens in January.

In Pulu atas I have also seen a solitary individual of a larger species of Heron, that, in the distance, appears to be pure white; this individual was well known to the natives of the atoll.

PELECANIFORMES.

Suborder FREGATI.

(7) *FREGATA AQUILA* Linn.

Native name, "Burung itam."

Does not breed in the main atoll, but nests in large numbers in Keeling Island. The nest is a slight collection of twigs, stolen from the nesting Gannets, and placed on the flat tops of the Pemphis bushes. The nests are crowded together in thousands; one egg only is laid, which is pure white and its surface is shining; eggs were abundant in June. The bird is so tame in Keeling that it has to be driven from the egg, and those birds that are sitting in the hot sun, with their wings half spread, may easily be approached and lifted from the ground.

(8) *FREGATA ARIEL* Gould.

This species is more common than the last. Its habits are similar, and it nests freely with the larger species. It is also called Burung itam by the natives.

Suborder SULÆ.

(9) *SULA SULA* Linn.

Native name, "Burung bebek."

I have never seen this bird in the main atoll, and its numbers are somewhat limited in Keeling Island. It lays one or two dirty white eggs on the bare ground, at the top of the western sand-beaches.

(10) *SULA ABBOTTI* Ridgw.

Native name, "Burung gangsa."

Is not common in Keeling, and, so far as I have observed, does

not come to the Southern group. The face is black, and the bird is considerably larger than the other two species. One or two eggs are laid on the bare ground. The black mask gives the sitting bird a very curious appearance, and it leaves its egg only after having, with great solemnity, vomited large quantities of fish; it makes no attempt to resist being pushed from the egg, and when the egg is taken, and the fish has been vomited, it quietly walks away. No skin was obtained.

(11) *SULA PISCATRIX* Linn.

Native name, "Burung main main."

The commonest of the three species, and generally called "Booby" by sailors in these seas. Exists in very great numbers, and is seen in all the many age changes of plumage, from a uniform light brown to white. It lays one egg, in a nest placed, as a rule, high up in trees; but numbers build on Pemphis bushes in Keeling. The birds commonly perch on trees, and are often taken from the rigging of ships.

Suborder PHAETHONTES.

(12) *PHAETHON RUBRICAUDA* Bodd.

Native name, "Burung buntut."

Does not exist in great numbers, but still breeds in Pulu atas. This species, as well as *P. fulvus*, is to be seen everywhere between the atoll and Java Heads.

PASSERIFORMES.

Fam. PLOCEIDÆ.

Mr. H. O. Forbes mentions *Ploceus hypoxanthus* as one of the nesting species of the atoll; but no examples of it exist to-day.

(13) *MUNIA ORYZIVORA* Bp.

Native name, "Burung glatek."

Introduced, and has multiplied greatly; it is now one of the commonest birds of the atoll.

Fam. TURDIDÆ.

(14) *MERULA ERYTHROPLEURA* Lister.

Introduced from Christmas Island, and now very common, especially on Pulu tikus. The bird is remarkably tame, coming freely into rooms to obtain water. Has a rather pleasing song, which it utters in September and October. The nest is built in November, and the egg is very like that of the European Redwing.

Fam. ZOSTEROPIDÆ.

(15) *ZOSTEROPS NATALIS* Lister.

Introduced from Christmas Island. Confined to Pulu luar, where it exists in some numbers. In Christmas Island it is

known as Burung Waringin, but in Cocos-Keeling it has earned the name of Burung chinta or "love-bird."

"Golden plover," native name "Burung blebis," and "Curlew," are said to breed on some of the islands, but I never found the eggs, nor did I ever obtain a bird for identification. A flock of ducks is resident on Pulu panjang, and on the same island I have seen many small waders, but the wise policy of the islands is that these birds shall not be interfered with, and I cannot name the species. I have, however, shot a stray Snipe (*Scolopax gallinago* Linn.) from a small flock on Pulu tikus, and on the same island obtained a Swallow, *Hirundo gutturalis* Scop. These are the only visitors that came to the islands in my stay of fifteen months, and the atoll would seem to be altogether out of the track of any, save very wind-blown, migrants.*

Text-fig. 9.



Young *Gygis candida*, soon about to take its first flight ; the plumage is still mottled with buff-coloured feathers.

* In North Keeling atollon are large warrens, the nesting sites of "Mutton Birds"; during my visit to the atollon these birds were not present, but they evidently visit the place, for the purpose of breeding, in very large numbers.

In all probability they are *Puffinus brevicaudus* or *P. sphenurus*.

REPTILIA.

Species determined by G. A. BOULENGER, F.R.S., V.P.Z.S.

(A) LACERTILIA.

Fam. GECKONIDÆ.

(1) LEPIDODACTYLUS LUGUSTRIS D. & B.

Native name, "Cheechak."

A very abundant species, inhabiting dwelling houses, and also living beneath the loose bark of coconut palms. Six or seven eggs are laid at a time—as a rule beneath some convenient chink of bark. It has the characteristic voice of its family, which has given rise to its name.

(2) GEHYRA MUTILATA Wiegman.

Not nearly so common as the first species, and lives exclusively out of doors, being always found beneath the bark of the coconut palms. It is at once distinguished from No. 1 by its flattened tail. It lays from three to four eggs, and the incubation period is as long as two months (June to August).

(B) OPHIDIA.

Fam. TYPHLOPIDÆ.

(3) TYPHLOPS BRAMINUS Daud.

Native name, "Ular minyak."

This is not a common species in the islands, and its habits lead to its being very rarely seen. It is most commonly found beneath large coral boulders, and it is extremely active. It is found on practically all the islands in the atoll. The average length is 150 millimetres.

None of these species is found in Christmas Island.

(C) CHELONIA.

Two species of Turtles are frequently speared in the lagoon. They are *Chelone imbricata* L., native name "Pinnew sisih," and *C. mydas* L., native name "Pinnew betul." Both have ceased to use the main atoll as a breeding place, for the native demand for them is too great; but on Keeling atoll their nests are common on the sandy beaches.

Accidental visitors.—From time to time other reptiles have been washed ashore. Several large snakes have floated to the islands, and have been picked up dead, or dying, on the beaches. Some few have survived the journey, but none has made a successful footing. At least two crocodiles have survived the six hundred miles of ocean travel: one was shot by the Governor, and one, after being repeatedly seen, disappeared after a cyclone.

PISCES.

The fish of the group were not collected, but no doubt a rich harvest awaits the investigator of the myriad smaller coral-haunting species. The native names of those that are of the most economical importance only are given here; and no specific determination is possible in most cases.

(1) Ikan babi = pig fish, *Balistes* sp. (2) Ikan buntal = inflated fish, *Tetrodon patoca*. (3) Ikan buntal besagi = square-shaped inflated fish, *Tetrodon* sp. (4) Ikan blana. (5, 6) Ikan bandang and Ikan bandang laut. (7) Ikan buntut burih = spotted tail. (8) Ikan chuchut, generic name for the numerous Sharks. (9) Ikan dongol, *Scarus* sp., grows to a great size. (10) Ikan grâpu. (11) Ikan iju = green-fish, *Pseudoscarus* sp. (12) Ikan jengot = bearded fish. (13) Ikan jengot karang (karang = coral). (14) Ikan kakap. (15) Ikan kakap kuning = yellow kakap. (16) Ikan kakatua iju, *Scarus* sp. (17) Ikan kakatua merah = red kakatua, also a *Scarus*. (18) Ikan merah = red fish. (19) Ikan malam = night fish. (20) Ikan menyrat. (21) Ikan padang döeh, the albicore. (22) Ikan p'dang, *Histiophorus gladius*. (23) Ikan pareh, *Dicerobatis eregoodoo*, grows to a great size, being upwards of 13 feet across the back. (24, 25) Ikan peteh, and Ikan peteh kuning. (26) Ikan puti = white fish. (27) Ikan palo. (28) Ikan sambar. (29) Ikan samsi. (30) Ikan skagnol. (31) Ikan talam talam. (32) Ikan talang. (33) Ikan tangiri, the king fish. (34) Ikan todak, the baracouta. (35) Ikan trompet.

It is to be hoped that, with the free communication that the Telegraph-station affords, some attempt may be made to get together a collection of the fish of the atoll: and for the purpose of assisting any collector, this incomplete list of the native names is published.

LEPIDOPTERA.

LEPIDOPTERA RHOPALOCERA.

(Native family name, "Kupu kupu.")

Species determined by Mr. F. A. HERON.

(1) PRECIS VILLIDA Fabr.

This is the commonest butterfly in the atoll. It is most abundant in July and September, and again in March and April. The larva is black, and is covered with spines: food-plant is *Asystasia coromandeliana*. The pupa is suspended by the tail from the branches of its food-plant, it is mottled brown and has no metallic markings. The pupal stage lasts for a fortnight or three weeks.

(2) HYPOLYMNAS BOLINA Linn.

(3) *HYPOLIMNAS BOLINA* form *NERINA* Fabr.

An uncommon species, on the wing in April and August. Specimens are in perfect condition, and the species is evidently resident.

(4) *HYPOLIMNAS MISIPPUS* Linn.

A common species on all the islands of the group. One worn specimen was taken on Christmas Island by Dr. Andrews. The males and females of this species are very rarely seen together; the males flying high in the shade of the thickly growing coco-palms, and the female being generally seen flying low over the herbage in open spaces. It is abundant from July to October, and again from the end of February to April. The larva is brown and spiny, the head is reddish and bears two spines. It feeds on a succulent weed that grows all over the open spaces in the atoll. The pupa is brown and has no metallic markings; it is suspended by the tail. Six days are passed in the pupal stage. The female mimics *Danaïs* (*Limnas*) *chrysippus petilia* Stoll, and is nearly always seen flying in company with that species, whose habits of fluttering over the herbage it has closely imitated. The male, on the other hand, flies strongly and is not often seen fluttering near to the ground.

(5) *VANESSA KERSHAWI* McCoy. (Australian.)

Only four examples of this species were met with in fifteen months, and since all were observed between the 15th and 17th of May 1906, it is probable that they were waifs. Two rather worn specimens only were captured on Pulu tikus.

(6) *DANĀIS* (*LIMNAS*) *CHRYSIPPUS PETILIA* Stoll. (Australian & Christmas Id.)

Common on Pulu luar and Pulu tikus, but not so often met with on the other islands. The larva is pale green, banded with yellow and black. The food-plant is *Asclepias curassavica*. The pupa is suspended by the tail, and is pale green or buff with small golden dots. The average stay in the pupa is only 135 hours.

LEPIDOPTERA HETEROCERA.

Species determined by Sir GEORGE F. HAMPSON, Bt., F.Z.S.

ARCTIADÆ.

(1) *UTETHESA PULCHELLOIDES* Hmps.

A very abundant insect on all the islands. It mostly frequents the seaward side, for there the food-plant, *Tournefortia argentea* Linn., lives most luxuriantly. The perfect insect, and the larvæ, are to be seen at all times of the year, and season appears to make no difference to its numbers.

NOCTUIDÆ.

(2) *CHLORIDEA OBSOLETA* Fabr.

No specimens were taken during 1905, and the insect only became at all plentiful in June 1906.

(3) *CHLORIDEA ASSULTA* Guen.

Appeared at the same time as the last species, and was not seen in any numbers.

(4) *CIRPHIS LOREYI* Dup.

Not an abundant insect, and strictly confined to a seasonal appearance. Taken in June 1905 and not again until the same month in 1906.

(5) *PRODENIA LITTORALIS* Boisd.

Abundant on all the islands, on the wing most plentifully in May and June. The larva feeds on a multitude of low-growing plants. This very widely distributed species is found on Christmas Island.

(6) *SPODOPTERA MAURITIA* Boisd.

Several specimens were taken in June 1905, but in June 1906 it did not appear again.

(7) *LEOCYMA SERICEATA* Hmps.

Not abundant, appears in June and again in November. The larva is pale green and bears a few scattered hairs, it feeds on the leaves of the Waroo (*Hibiscus tiliaceus* Linn.). Not on Christmas Island, though its genus is represented by *L. tibialis* Fabr.

(8) *OPHIUSA CORONATA* Fabr.

Only one specimen taken, and a few more seen, in June 1905. Occurs on Christmas Island.

(9) *OPHIUSA MELICERTA* Dru.

This is one of the most plentiful of the atoll insects, being found wherever the bushes of *Pemphis acidula* (native name "Kayu burung") are growing. It is on the wing practically all the year round, but is most common from June to September. The larva bears a wonderful resemblance to the twigs of the *Pemphis acidula* or the *Ricinus* on which it feeds. It has a habit of dropping from its twig when disturbed, but it always manages to get a fresh hold of a lower twig, on the way down, although it appears to be falling to the earth. It pupates in a few leaves spun together at the ends of the twigs; the pupa is covered with a fine bloom. Fourteen days are passed in the pupal state.

(10) *REMIGIA FRUGALIS* Fabr.

Most abundant in May, and a few stragglers again in September. It flies by day, and is not uncommon in the grassy spaces, where the undergrowth is kept cleared.

(11) *PLUSIA CHALYCTES* Esp.

The development of a garden on Pulu tikus appeared to be the cause of the abundance of this species; but since the garden plants were introduced as seed, there appears but little chance of their having been the agent for its introduction. It swarmed in June 1906, and the green larva was abundant on peas, tomatoes, and almost every plant that was grown in the garden. The pupal stage lasts only a week.

(12) *HYPENA STRIGATA* Fabr.

One example only taken.

(13) *CATEPTRIA* sp.

This is a handsome insect, boldly marked with black and white. It appears on the wing in September. The larva feeds on the leaves of *Pemphis acidula*, in company with *Ophiusa melicerta*, to which larvæ it bears a considerable rough resemblance. It is mottled grey on the back, and the belly is velvety black; at the anal extremity is an upwardly directed tubercle with a bifid tip. A collar of magenta colour surrounds the larva behind the head, but in all ordinary attitudes this is hidden by a skin-fold. It pupates among the little leaves of its food-plant; the pupa has no bloom, and the pupal stage lasts for twenty days. I never saw an example of the perfect insect, save those that I reared from larvæ; and, so far as I could find out, no one on the island was acquainted with the moth. The larvæ were by no means uncommon on a few bushes in Pulu tikus, but I did not meet with them on any other islands.

SPHINGIDÆ.

(14) *MACROGLOSSA PASSALUS* Dru.

By no means common, and more frequently seen as a larva than as an imago. On the wing in September. Larva green with fine bright pink side-stripes; feeds on *Morinda citrifolia* Linn., native name "Mungkoodoo." The pupa is a mottled yellowish-brown.

(15) *CEPHONODES HYLAS* Linn.

Common on Pulu tikus, but not often seen on the southern islands. Frequents the flowers of the *Papaia* by day, and is evidently the source of the error that bees are common in the islets. When hovering in front of the food-plant, in the act of laying its eggs on the leaves, the long hairs of the extremity of the body stand out like a fan. Most abundant in June and September, but stragglers may be taken in almost any month.

Larva feeds on the leaves of *Guettarda speciosa* Linn., native name "Melati." When first hatched they are quite black, and they only become green in their penultimate and ultimate skins. They are subject to endless variation, and if bred in the dark, very striking larvæ, coloured yellow and black, can be produced; the imagines resulting from these larvæ are normal. This insect occurs on Christmas Island.

(16) *HERSE CONVULVULI* Linn.

Not a very common insect. Found most plentifully on Pulu Selma. The larva is either green or brown, and it feeds on *Convolvulus parviflorus* Vahl. In the atoll this is the moth specially named "Rama rama," although in the Straits that word is the general name for all moths.

(17) *CHÆROCAMPA VIGIL* Guer.

The perfect insect is rarely seen, but the larva is very abundant in September. It feeds on the leaves of *Pisonia inermis* (native name "Ampol"); it is green, but in its last skin it frequently becomes putty-coloured. When fed in the dark the last skin is almost invariably brown. A month is passed in the pupa. This species occurs on Christmas Island.

GEOMETRIDÆ.

(18) *CHLOROCYSTIS TENUILINEA* Warr.

Not uncommon in June and August. The larva is green, with darker markings, and is slightly hairy. Feeds on the sticky flowers of *Pisonia*, and pupates among them.

PYRALIDÆ.

(19) *PYRALIS MANIHOTALIS* Guer.

Not at all plentiful.

(20) *MELISSOBLAPTES* sp.

Very abundant on all the islands of the group.

(21) *ZINCKERNIA FASCIALIS* Cram.

Always common. This widely distributed species also occurs on Christmas Island.

(22) *MARASMIA VENIHALIS* Walk.

One of the commonest insects. Appears in June, and is always to be found about the station lamps.

(23) *CROCIDOLomia BINOTALIS* Zell.

Only a few examples met with in June.

(24) *PACHYZANCLA LICARSISALIS* Walk.

Abundant from June to August. The larva is green, with

minute black spots ; it feeds on the leaves and flowers of *Dicliptera burmanni* Nees. It pupates in the spun-up leaves, and the pupal stage lasts for fourteen days.

(25) *PACHYZANCLA STULTALIS* Walk.

Abundant in June on all the islands.

(26) *GLYPHODES INDICA* Saund.

Not abundant.

PTEROPHORIDÆ.

(27) A brownish coloured Plume is very common in all the islands. The larva feeds on *Boerhavia diffusa* W., which grows everywhere in the atoll.

TINEINA.

(28) The solitary species collected was a very common one ; there are probably at least two others that are distinct.

There are therefore practically thirty species of Heterocera on the Cocos-Keeling atoll, and there are more than twice as many species in the fauna of Christmas Island ; yet only five, very widely distributed species, are common to the two places.

HYMENOPTERA.

Species determined by the late Col. C. T. BINGHAM, F.Z.S.

FORMICIDÆ.

(Native family name, "Samut.")

(1) *ODONTOMACHUS HÆMATODES* Linn. ♂.

(2) *PLAGIOLEPIS LONGIPES* Jerdon. ♀.

Unfortunately this does not represent the whole of the species of ants found on the atoll. The natives distinguish at least three species :—(1) "Samut saman" ; (2) "Samut arpi" ; (3) "Samut alus." The other representatives of the family are unfortunately mislaid.

FOSSORES.

(3) *STIZUS* sp. (very near *reversus* Smith). ♀.

(4) *PISON HOSPES* Smith. ♂.

(5) *NOTOGONIA SUBTESSELLATA* Smith. ♂ ♀.

None of the Fossores is at all numerous, and only very careful collecting produced the very few specimens obtained in the course of fifteen months.

None of these species is represented in the fauna of Christmas Island.

DIPTERA.

Species determined by E. E. AUSTEN, F.Z.S.

ASILIDÆ.

- (1) *PHILODICUS JAVANUS* Wied.

A common insect of very voracious habits. It is generally seen sitting on the coral boulders, in the hottest sunshine. It lies in wait for smaller diptera, and it will attack and kill even butterflies as large as *Precis villida*.

BOMBYLIDÆ.

- (2) *ANTHRAX* sp. Only a very few examples met with.

DOLICHOPODIDÆ.

- (3) New genus and species (No. I.), near *Psilopus*.

- (4) New genus and species (No. II.), near *Psilopus*.

Both of these are common insects, but owing to their green colour and small size, they are not at all conspicuous. They are shining green flies that are most commonly seen running on the leaves of the *Hibiscus*. They are extremely active, and are generally found during the hottest hours of the day.

MUSCIDÆ.

- (5) *SARCOPHAGA* sp. No. I.

- (6) *SARCOPHAGA* sp. No. II.

Both are common species, frequenting the dead bodies of rats.

- (7) *RHINIA TESTACEA* Rob.-Desv.

Few examples seen, mostly upon the herbage of the seaward side of the islands.

- (8) *PYCNOSOMA FLAVICEPS* Macq.

The commonest fly in the atoll.

- (9) *OPHYRA CHALCOGASTER* Wied.

MICROPEZIDÆ.

- (10) *NERIUS LINEOLATUS* Wied.

HIPPOBOSCIDÆ.

- (11) *PSEUDOLFERSIA SPINIFERA* Leach.

Usually swarming over the plumage of the Frigate-birds. On

Keeling atollon, where these birds breed in thousands, the fly is often seen crawling about the nesting bushes.

CULICIDÆ.

(12) The Mosquito of the islands is a species of *Stegomyia*, and it exists in great numbers.

COLEOPTERA.

Species determined by C. O. WATERHOUSE, P.E.S.; C. J. GAHAN, M.A., F.E.S.; and G. J. ARROW, F.E.S.

BRACHELYTRA.

(1) ALEOCHARA sp. This genus is not represented on Christmas Island.

CLAVICORNIA.

(2) DERMESTES FELINUS Fabr.

A common species, found mostly in the dead bodies of rats. Universal distribution, and common on Christmas Island.

(3) COCCINELLA TRANSVERSALIS Fabr.

A very abundant insect; not present on Christmas Island.

(4) TROCHOIDEUS DESJARDINSI Guer.

Not present on Christmas Island.

LAMELLICORNIA.

(5) ONTHOPHAGUS sp.

Genus not represented on Christmas Island.

(6) ANOMALA sp.

An abundant species that lives on the iron-wood (*Cordia subcordata*). Freely attracted to light and most commonly found in the lamps of the Telegraph-station. Not found on Christmas Island.

(7) POTATIA ACUMINATA.

The largest beetle found on the atoll. It is by no means common, and not more than a dozen specimens were taken in fifteen months. Not present on Christmas Island.

MALACODERMATA.

(8) CORYNETES RUFIPES De Geer.

Native name, "Kutu copra."

The most important insect of the atoll, from an economical point of view. Called by Europeans the "Copra beetle." Exists

in myriads near to the sheds where the copra is stored. It will swarm to anything oily, and was killed in thousands on the refrigerator engines. It is very active, it flies by day, and has a habit of creeping beneath the clothing and biting rather sharply. It does not occur on Christmas Island.

SERRICORNIA.

(9) MEGAPENTHES sp.

Not a common insect. It does not occur on Christmas Island, where *M. andrewsi* Waterh. is the representative of the genus.

(10) MELANOXANTHUS MELANOCEPHALUS Fabr.

One specimen only, flying in the sunshine, on March 2, 1906. Does not occur on Christmas Island, but the genus is represented there by *M. dolosus* Cdz. and *M. litura* Cdz.

HETEROMERA.

(11) OPATRUM sp. (near *simplex* Fabr.).

A common insect, found mostly under the bark of the coconut palms. Does not occur on Christmas Island, where the genus is represented by *O. dubium* Arrow.

(12) CEROPRIA INDUTA Wied.

Very abundant on all the islands. Lives in rotting wood. The genus is not present on Christmas Island.

(13) SESSINIA sp.

Native name, "Madû."

A very common insect. Found on all the islands, and freely attracted to light. It is the subject of great variations in size.

Well known to the inhabitants, Malay and European, as producing an acute dermatitis by contact, and an acute urethritis when swallowed in drinks; for this reason drinks are always carefully covered over to prevent the beetles from falling in. Concerning these properties of the insect there is no doubt, and although I have failed to produce the urethritis by swallowing a decoction of two beetles in a glass of whiskey and soda, I have met with several cases in which its development is definite, and have frequently seen the cutaneous lesions.

This species would appear to be very similar to, if not identical with, *S. andrewsi* Arrow, from Christmas Island; and of that insect Dr. Andrews says that it exudes an oily liquid, "which is considered by the residents to have most injurious properties" ('Monograph of Christmas Island,' p. 107).

LONGICORNIA.

(14) CERESIUM SIMPLEX Gyll.

Rare. Not found on Christmas Island, but two representatives

of the genus—*C. quadrimaculatum* Gahan and *C. nigrum* Gahan—were taken there by Dr. Andrews.

(15) *CALOCYCLUS ANNULARIS* Fabr.

Only one specimen taken, flying in the sunshine, on March 1st, 1906. Does not occur on Christmas Island.

(16) *RHOPICA HONESTA* Pasc.

(17) *RHOPICA BINOTATA* Gahan.

Both unique specimens. The genus is not represented on Christmas Island.

Seventeen species of beetles therefore occur on the Cocos-Keeling group, and only one—a cosmopolitan species—is definitely known to be also an inhabitant of Christmas Island, although the coleopterous fauna of that island embraces ninety-five species.

RHYNCHOTA.

By W. L. DISTANT, F.E.S.

Suborder HETEROPTERA.

Fam. PENTATOMIDÆ.

Subfam. CYDNINÆ.

(1) *GEOTOMUS PYGMÆUS*.

Æthus pygmeus Dall. List Hem. i. p. 120 (1851).

Geotomus pygmeus Sign. Ann. Soc. Ent. Fr. (6) iii. p. 51, t. iii. f. 160 (1883); Dist. Faun. B. I., Rhynch. i. p. 98, f. 49 (1902).

Hab. Widely distributed: recorded from Ceylon, Bombay, Burma, Andaman Islands, and generally distributed throughout the Malayan Archipelago; found in China and Japan, and recorded from New Caledonia and Hawaii.

Subfam. PENTATOMINÆ.

(2) *NEZARA VIRIDULA*.

Cimex viridula Linn. Syst. Nat. ed. 10, p. 444 (1758).

For full synonymy cf. Dist. Biol. Centr.-Am., Rhynch. i. p. 78 (1880).

This species is distributed throughout the Palearctic, Nearctic, and Ethiopian regions, and over a large portion of the Neotropical, Oriental, and Australian regions.

Subfam. ASOPINÆ.

(3) *OECHALIA CONSOCIALIS*.

Pentalatoma consocialis Boisd. Voy. Astrol., Ent. ii. p. 630, t. xi. f. 9 (1835).

Oecalia consocialis Stål, Enum. Hem. i. p. 59 (1870); Schont. in Wytsm. Gen. Insect., Fasc. 52, p. 75, t. v. f. 12 (1907).

This species is recorded from, and not uncommon in, Australia, New Zealand, and Tasmania. It is a well-known species in Queensland.

Fam. ARADIDÆ.

(4) BRACHYRHYNCHUS MEMBRANACEUS.

Aradus membranaceus Fabr. Syst. Rhyng. p. 118 (1803).

Brachyrhynchus membranaceus Stål, Hem. Fabr. i. p. 96 (1868); Dist. Faun. B. I., Rhyng. ii. p. 160 (1904).

Found throughout British India, Malay Peninsula, and Malayan Archipelago.

Fam. REDUVIIDÆ.

Subfam. NABIDINÆ.

(5) NABIS CAPSIFORMIS.

Nabis capsiformis Germ. in Selb. Rev. Ent. v. p. 132 (1837); Dist. Faun. B. I., Rhynch. ii. p. 400, f. 256 (1904).

Distributed in the Nearctic, Palearctic, Ethiopian, Oriental, and Australian Regions.

Fam. CAPSIDÆ.

(6) LYGUS sp.?

Two specimens of a species of this widely distributed genus.

[None of these species can be described as at all abundant on the atoll, and only *Nezara viridula* is commonly met with; the others are, for the most part, very seldom found. The whole of the order collected on Christmas Island by Dr. Andrews was not worked over at the time of publication of his Monograph; but of the four species described by Mr. Kirby, there is not one that is common to Christmas Island and the Cocos-Keeling atoll. So far as I know, none of these species has earned a distinct native name, but the domestic representative of the family, which is common in native houses, is called "kutu basuk" = stinking insect.—F. W. J.]

Suborder HOMOPTERA.

Fam. FULGORIDÆ.

Subfam. RICANIINÆ.

(1) NOGODINA BOHEMANI.

Ricania bohemani Stål, Freg. Eugen. Resa, p. 280 (1858).

Nogodina bohemani Melich. Ann. Hofmus. Wien, xiii. p. 305, t. xiv. f. 9a (1898).

Originally described from the Keeling Islands.

[This is not a common insect, and only a few examples were taken, all from the leaves of the Hibiscus trees on the seaward side of Pulu tikus.—F. W. J.]

NEUROPTERA.

Species determined by W. F. KIRBY, F.L.S., F.E.S.

ODONATA.

(Native family name, "Kachapong.")

(1) PANTULA FLAVESCENS Fabr.

A very abundant insect; it flies about all over the lagoon, and is present on all the islands. In April and May of 1906 the whole atoll swarmed with dragonflies, but for some time previous to that it had been very rare to meet with a single specimen. In the early months of 1905 these insects were entirely absent from the atoll.

(2) TRAMEA ROSENBERGII Brauer.

First seen on May 16th, 1906, and during the following week it became abundant; but for nearly a year previous to this it had not been seen, and its numbers soon diminished afterwards.

(3) ANAX GUTTATUS Burm.

This species also came first to the atoll in May 1906, and then only about a dozen examples were seen.

None of these species is resident on the atoll, and there is no open fresh water for them to pass their early stages in. All are wind-borne waifs, and do not belong properly to the fauna of the islands, although they are at times so conspicuous a feature of it.

Pantula flavescens appears to fly over the surface of the sea from choice, and not to be, by any means, an involuntary traveller; on the two occasions on which I have sailed from Java to the atoll, I have seen—on calm days—many dragonflies hawking about above the water. It is not easy to see what they are seeking, and yet they do not seem to be flying about merely at the sport of the wind. In November of 1906, whilst lying 20 miles to the south of the island of Sumbawa, these dragonflies were seen every day, during ten days of calm, to be flying in all directions over the surface of the sea, and as great numbers of butterflies and other insects were also to be seen, it is probable that they were in quest of food; any question of their being blown from the land was quite impossible. In 1907, during a spell of quite remarkable calm, dragonflies were seen on practically every day of a voyage between Sydney and Singapore.

On the atoll itself, *Tramea rosenbergii* was often seen to copulate, and apparently to deposit its eggs in the salt pools, but none of its larvæ could ever be found. *Pantula flavescens* and *Anax guttatus* are both visitors to Christmas Island.

PLANIPENNIA.

(4) HEMEROBIUS ? sp.

Native name, "Lalar ijou," = green fly.

This is a very abundant insect; it occurs on all the islands, and is certainly resident. When alive it is bright green, and its eyes are remarkably brilliant. On account of its very offensive smell when crushed, it is very well known. It is common at all seasons of the year.

(5) ISOPTERA.

Native name "Gegat."

One species of "white ant" is very abundant in the wood-work of dwelling houses. It is noteworthy that the natives never include this insect under the title of Samut,—the family name for ants.

ORTHOPTERA.

Species determined by W. F. KIRBY, F.L.S., F.E.S.

FORFICULIDÆ.

(1) ANISOLABIS ANNULIPES Luc.

A common species found upon all the islands. It does not occur on Christmas Island.

BLATTIDÆ.

(Native generic name, "Kerklak.")

(2) BLATELLA GERMANICA Linn.

(3) ALLACTA NOCTULATA Stål.

(4) ALLACTA OBTUSATA Brunn.

(5) LOBOTERA sp.

(6) MOLYTRIA sp. (young larva).

(7) LEUCOPHŒA SURINAMENSIS Linn.

All these species are common, and are mostly found beneath the bark of trees, or in the dwelling-houses. Only *Leucophœa surinamensis* occurs on Christmas Island.

(8) PERIPLANETA AMERICANA Linn.

Common in store-houses; introduced by ships.

ACHETIDÆ.

(9) GRYLLODES SIGILLATUS Walk.

Native name, "Orong Orong."

Most commonly taken near to dwelling-houses; not very abundant.

(10) ORNEBIUS sp.

A very abundant species. It lives in the bushes of ironwood (*Cordia subcordata*), and passes its early stages in a rolled-up leaf.

Neither of these species occurs on Christmas Island.

(11) GRYLLACRIS sp. near *signifera* Stål.

Native name "Chingkrek."

This species also passes its early stages in the leaves of the *Cordia*. When adult it appears to be carnivorous; it has exceedingly powerful jaws, and is credited with waging war on the large centipedes. When put in a box with a centipede it certainly fights with great vigour, and though it bites the centipede, the fights that I have arranged ended fatally for the *Gryllacris*,—but I believe that this is by no means invariable. This species does not occur on Christmas Island, but the allied *G. rufovaria* takes its place. The antennæ are 150 mm. long.

(12) PHISIS PECTINATA Guer.

A fairly common species, usually found in the *Cordia* bushes. It is a bright green when living. It is not found on Christmas Island, but *P. listeri*, that occurs there, is very nearly allied to it.

(13) CONOCEPHALOIDES SOBRINUS Bol.

The male is buff-coloured, and the female green, during life. The species is abundant, and commonly lives in bushes. It is very musical. Does not occur on Christmas Island.

LOCUSTIDÆ.

(Native name, "Blalang blalang.")

(14) ACRYDIUM, sp. near *japonicum*, Sauss.

Very abundant on all the islands. Feeds on the fronds of the coconut palm. It varies greatly in size when adult, and is the subject of great seasonal changes of abundance and rarity.

It is not found on Christmas Island.

Although fourteen species of Orthoptera are found on the Cocos-Keeling atoll, and twenty-three occur on Christmas Island, there is only one species—*Leucophœa surinamensis*—that is common to both places. Of this species Dr. Andrews took only a single specimen.

ARACHNIDA AND MYRIAPODA.

By A. S. HIRST, F.Z.S.

The Arachnida collected by Dr. Wood Jones include several species which are well-known to be distributed through human agency. Of the few remaining forms, two spiders and one myriapod seem to belong to undescribed species, but it is probable that they will prove to be Malayan or East Indian forms which have been introduced through trade with these regions or have reached the islands by natural means.

SCORPIONS.

- (1)
- ISOMETRUS MACULATUS*
- De Geer.

Native name, "Klajingking."

Cosmopolitan.

SPIDERS.

(Native family name, "Laba laba.")

- (2)
- SMERINGOPUS ELONGATUS*
- Vinson.

Cosmopolitan.

- (3)
- PHYSOCYCLUS GLOBOSUS*
- Taczan Taczanowski.

Widely distributed in the tropical regions of the world.

- (4)
- NEPHILA IMPERATRIX*
- C. K.

An adult female example, which apparently belongs to this species, was collected by Dr. Wood Jones. It differs from Koch's description of the species in having the abdomen marked ventrally with two dark median patches, the anterior one being square and separated from the smaller posterior patch by a whitish line. The British Museum possesses examples of this form from Buitenzorg, Java, and from Australia (Keyserling Coll.)

- (5)
- HETEROPODA VENATORIA*
- Linn.

Cosmopolitan.

- (6)
- LYCOSA*
- n. sp.

- (7)
- BAVIA*
- n. sp.

MILLIPEDES.

(Native name, "Kaki ribu.")

- (8)
- TRIGONIULUS*
- n. sp.

- (9)
- ORTHOMORPHA COARCTATA*
- Saussure.

(10) There is also a large Centipede—native name "Alipan"—no specimen of which reached England.—F. W. J.

CRUSTACEA.

(Native family name, "Kapeting.")

The collection of this order was not at all a representative one, such specimens as were brought home have been determined by Dr. W. T. Calman, F.Z.S.

BRACHYURA.

- (1) *CARUPA LÆVIUSCULA*.
- (2) *LEPTODIUS SANGUINEUS*.
- (3) *LIOXANTHO PUNCTATUS*.
- (4) *LIOMERA PUBESCENS*.
- (5) *ACTÆA FOSSULATA* ?
- (6) *CARPILIUS MACULATUS*.
- (7) *EURUPPELLIA ANNULIPES*.
- (8) *PSEUDOZIUS CAYSTRUS*.
- (9) *ERIPHIA LEVIMANA*.
- (10) *MELIA TESSELLATA*.
- (11) *GELASIMUS* sp.
- (12) *CARDISOMA HIRTIPES*.
- (13) *GECARCOIDEA LALANDEI*.
- (14) *LILOPHUS PLANISSIMUS*.
- (15) *SCHIZOPHRYS ASPERA*.
- (16) *CALAPPA HEPATICA*.

In addition to this list there are several members of the genus *Ocypoda* that live on the lagoon beaches, and several of the genus *Leptograpsus*, of which one, the native name of which is "Kapeting traieg," is eaten in the islands; a member of the genus *Geograpsus* is one of the common land species.

ANOMURA.

- (1) *REMIPES TESTUDINARIUS*.
- (2) *BIRGUS LATRO*.
- (3) *CÆNOBITA CLYPEATUS*.
- (4) *CÆNOBITA RUGOSUS*.
- (5) *CÆNOBITA PERLATUS*.
- (6) *CALCINUS HERBSTII*.
- (7) *CLIBANARIUS CORALLINUS*.

CARIDEA.

(1) ALPHEUS STRENUUS.

STOMATOPODA.

(1) GONODACTYLUS CHIRAGRA.

VERMES.

There is one species of earthworm found in all the islands, but unfortunately no specimen reached England.

2. Contributions to the Anatomy of certain Ungulata, including *Tapirus*, *Hyrax*, and *Antilocapra*. By FRANK E. BEDDARD, M.A., F.R.S., F.Z.S., Prosector to the Society.

[Received January 28, 1909.]

(Text-figures 10-19.)

I have during the past three or four years dissected and studied various organs in a number of Ungulate animals, to which group I have indeed paid special attention in view of the fact that for obvious reasons these mostly large animals have been comparatively little examined. Indeed, of two or three of the species of Antelopes to which I shall call attention in the following pages there is, so far as I am aware, absolutely no knowledge of the structure of certain of the soft parts. A good deal of work has been done upon this group lately by Dr. Einar Lönnberg, C.M.Z.S., and upon some of the genera with which I occupy myself in the following pages, viz., *Cephalophus*, *Madoqua*, and *Gazella*. I am able, however, to add something to the large number of facts which Dr. Lönnberg has accumulated in his various papers to which reference will be made in the proper places. The notes which I have to communicate to the Society may be arranged under the following headings, viz. :—

- (1) On the absence of a Pleural Cavity in the Indian Tapir, p. 161.
- (2) Notes upon the Brain and some other points in the Anatomy of *Hyrax*, p. 162.
- (3) On the Existence of a new Skeleto-visceral Muscle in the Pygmy Hog (*Porcula salvania*), p. 170.
- (4) Notes upon the Anatomy of the Prongbuck (*Antilocapra americana*), and on the Colic Helicine in some Artiodactyles, p. 172.
- (5) Some Notes upon the Anatomy of *Madoqua phillipsi*, p. 188.
- (6) The Brain of *Babyrussa alfurus*, p. 192.
- (7) Résumé of new facts, p. 196.

(1) *On the absence of a Pleural Cavity in the Indian Tapir.*

In dissecting, some months since, an example of the Indian Tapir (*Tapirus indicus*) which died in the Society's Gardens, I was struck by the close attachment of the lungs to the wall of the chest-cavity. This attachment was by means of fine and multitudinous strands of a glistening appearance precisely like a much subdivided mesentery, and was very complete; so much so that it would be quite fair to speak of the pleural cavity as practically non-existent in that animal. It is unnecessary to dwell upon the fact that the lungs were obviously not much moveable owing to this firm connection with the walls of the cavity containing them. Inasmuch as adhesions of a similar kind are by no means infrequent as a pathological phenomenon, it behoved me to decide very carefully whether, in the example of the Indian Tapir which exhibited the condition referred to, there was not some disease of the lungs or the pleura, or of both, which would account for this remarkable state of affairs. Although I have naturally accumulated during my long tenure of the Prosectorship of this Society some knowledge of morbid appearances and structures, I called in my then colleague, Dr. Seligmann, to my assistance, who confirmed my opinion. There can therefore be but little doubt that the condition described above in *Tapirus indicus* is the normal condition. It would appear, however, that this condition has been observed in the same animal and has been put down to the effects of disease. For Dr. Murie in his account of the anatomy of this Tapir * wrote:—"The examination of the thoracic cavity exhibited the residual effects of pleurisy, there being fluid exudation and adhesions between the parietes and the lungs." It is not so very likely that so competent an observer as Dr. Murie would be mistaken as to the presence of disease; but it must be borne in mind that a normal attachment of the lungs to the parietes would not prevent the lungs from being invaded by disease!

Again Dr. Cantor says † that his specimen of *Tapirus indicus* died from inflammation of the lungs, but he gives no detail. On the other hand, neither Poelman ‡ nor Sir Everard Home § say anything bearing upon the present matter.

The interest of this remarkable obliteration, partial at any rate, of the prediaphragmatic cœlom in *Tapirus indicus* largely depends upon the fact that the same state of affairs exists in the Elephant. Quite recently Boas || and more recently still Giard ¶ have shown, in accordance with the statements of others (Miall & Greenwood, &c., quoted by Giard), that the lungs are firmly adherent to the

* "On the Malayan Tapir, &c.," J. Anat. Phys. vi. 1872, p. 139.

† "Cat. of Mammals inhabiting the Malayan Peninsula and Islands," Journ. Asiat. Soc. Bengal, xv. 1846, p. 266.

‡ Mém. Ac. Roy. Belg. xxvii. 1853.

§ Phil. Trans. 1821, p. 272.

|| "Fehlen der Pleurahöhlen beim indischen Elefanten," Morph. Jahrb. Bd. xxxv 1906, p. 494.

¶ "L'Éléphant de Afrique a-t-il une cavité pleurale," C. R. Acad. Sci. t. cxliv. 1907, p. 306.

parietes by matted ligamentous cords in both *Elephas africanus* and *E. maximus*. M. Giard goes on to suggest that the same may be the case with *Hyrax capensis*, quoting apparently confirmatory evidence from the well known memoir of George upon that animal. I myself am unable to confirm this suggestion from my dissections of several examples of both *Hyrax capensis* and *H. dorsalis*. Still there remains the Elephant, which seems most undoubtedly to resemble the Indian Tapir in this remarkable specialisation. It is difficult to form an opinion as to whether any stress is to be laid upon the fact that both these animals are Ungulates.

(2) *Notes upon the Brain and some other points in the Anatomy of Hyrax.*

The Society acquired some months ago the temporary possession of a considerable number of examples of *Hyrax capensis*, which were all about half-grown. The measurement of one individual (and all were of about the same size) was a foot or so in length. The dissection of so large a series of specimens has enabled me to add some facts to what is already known about the structure of this primitive Ungulate. I shall deal with such organs as I have specially investigated *seriatim*, and shall in some cases be able to compare them with the corresponding organs of *H. dorsalis*, of which I have dissected two examples.

Azygos vein.—I have already described* the condition of this vein in *Hyrax* and quoted the descriptions of others. It is evident from what has been written on the subject, that the prevailing arrangement in *Hyrax* is the presence of a single azygos only, and that on the right side. In all the examples to which the present note refers, this arrangement of the azygos was found. The comparative constancy of the azygos, upon which I have already ventured to insist, is thus established for the present species.

The *Brain* of *Hyrax* has been figured by several anatomists. Thus Serres gives in his 'Anatomie Comparée du Cerveau'† two views of the brain. Later Daresté reported‡ upon three brains which were not very well preserved. Of these he wrote that they "s'éloignaient du type des Pachydermes pour se rapprocher de celui des Carnivores"—no hint, here, it will be noted, of any Rodent affinities. Some years later Gervais§ figured a cast of the brain in his well-known paper upon the mammalian brain. The most complete series of figures known to me of the brain of this 'Subungulate' are those of George in his monograph|| upon *Hyrax*. The brain is figured in many views and very thoroughly. The brain of *Hyrax* is also figured by Sir Richard Owen in his

* "The Azygos Veins in Mammals," P. Z. S. 1907, p. 193.

† 1824-1827, pl. 15, figs. 269, 273.

‡ Ann. Sci. Nat. (4) iii. 1855.

§ Journ. de Zool. 1872.

|| "Monographie du Genre Daman" Ann. Sci. Nat. (6) i. 1874, pl. xvi.

text-book*. The most recent account known to me is that of Dr. Elliot Smith in the Catalogue of the Physiological Series in the Museum of the Royal College of Surgeons†.

I have examined altogether fourteen brains of *Hyrax capensis*, which permits me to contribute something to what is known of the variations of the sulci in this Subungulate. None of these brains, I should add, was among those studied by Dr. Elliot Smith. This anatomist has studied seven brains and finds "that the features of the brain vary greatly in different specimens." In addition to the brains of *Hyrax capensis*, I have examined one brain of *H. dorsalis*. I shall now proceed to review such variations as are exhibited in the fourteen brains of *H. capensis*, commencing with the dorsal surface.

The *splénial sulcus* is figured by Elliot Smith as invisible posteriorly upon the dorsal surface; its position for the last 5 mm. or so of its length is mesial and lateral, and it is therefore not to be seen when the brain is regarded from the dorsal surface. This was also the case with four of the brains examined by myself. In the others the sulcus could be seen dorsally for its entire length. This was also very markedly the case with the one brain of *H. dorsalis*.

As a rule, the splénial sulcus is quite independent of the coronary and lateral sulci. The blood-vessel running along it, however, is formed by two branches, one behind the other, to the vessel running along the coronary sulcus. These naturally slightly indent the surface of the brain. But in two specimens only out of the entire series, and in them only on the right side, was there a distinct furrow joining the splénial to the posterior end of the coronary. This furrow represents an extension of the small notch figured by Elliot Smith‡ as lying between the coronary and lateral sulci. The occasional completion of this fissure is of course suggestive of other Ungulates\$. The *coronary* fissure does not always stop short of the transverse fissure or notch in the middle of the length of the brain which has just been referred to. This was, however, the case with six brains. In the others the coronary fissure was connected by the transverse fissure with the suprasylvian.

In the single brain of *Hyrax dorsalis* there was no connection between the coronary and the suprasylvian.

The *lateral* fissure showed no variations except very slight ones of length.

The lateral view of the brain is figured by Elliot Smith in two examples, which differ very considerably. I have also found a certain number of variations in the sulci of this region of the brain, which are the following:—

In eight examples I found the *suprasylvian* fissure to be very

* 'Anatomy of Vertebrates,' vol. iii, fig. 96.

† 2nd ed. vol. ii. p. 297. Dr. Elliot Smith quotes also a memoir by Turner (J. Anat. Phys. xxv. 1891) and Krueg's well-known paper; see also Elliot Smith, Trans. Linn. Soc., Zool. (2) viii. p. 400.

‡ *Loc. cit.* p. 297, fig. 168.

§ See below, p. 173, and text-fig. 11.

slightly bowed and not nearly reaching the rhinal fissure; and the single brain of *Hyrax dorsalis* agreed with these. In the remaining brains the suprasylvian fissure was carried on to the rhinal. I found an *orbital* fissure in all of the brains, and in five or six there were more or less well-developed traces of a preorbital fissure which did or did not join the rhinal fissure and rarely joined the coronary above; in the latter event the fissure did not communicate with the rhinal.

On the temporo-occipital region of the brain, *i. e.* behind and below the suprasylvian fissure, I find the existence in varying proportionate degrees of three more or less parallel fissures which are vertical in direction—and not of two only as figured by Elliot Smith. The most anterior of these is, however, obviously represented by the lowermost section of the suprasylvian fissure figured in one of Dr. Elliot Smith's illustrations*. For I have found in some brains where the suprasylvian fissure is as strongly bowed as in the illustration referred to, that the suprasylvian fissure ends anteriorly in a Y-shaped bifurcation of which in other brains one or other limb may be entirely or partly absent. In the brain figured by Dr. Elliot Smith †, as in a brain among those examined by myself, the upper anterior limb of the bifurcation is absent; whereas in the second brain figured by Elliot Smith it is, as I also have seen, the lower part of the fork which has vanished.

These three fissures seem to me to vary from individual to individual and on both sides of the brain of the same individual very often. The principal variations in the specimens examined by myself were the following:—The most anterior of the three fissures was quite absent or represented by a small rudiment which did or did not join either the rhinal or the suprasylvian fissure, or finally it effected a complete junction between these two fissures. The middle fissure which Elliot Smith letters in his drawings as the Sylvian is sometimes longer, sometimes shorter; sometimes it starts from the rhinal fissure and is sometimes unconnected with that fissure. It is occasionally broken into two smaller fissures lying one above the other. More rarely, it is connected by a transverse fissure (*i. e.* one running horizontally) with the third of the three fissures referred to and which Elliot Smith terms postsylvian. This fissure again varies very much in length and sometimes joins the suprasylvian. Very rarely it joins the rhinal below.

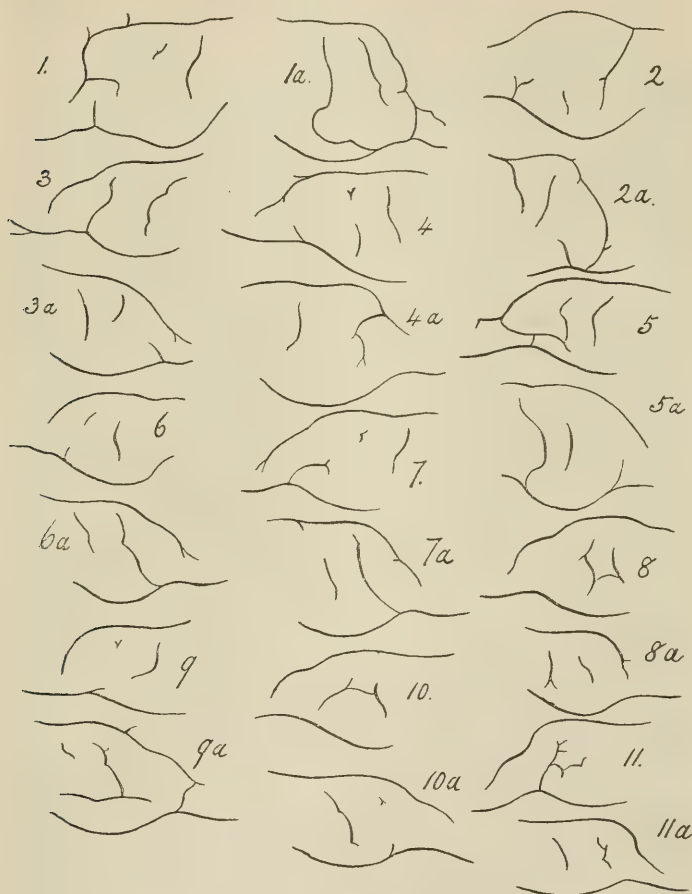
These variations are shown in the accompanying figure (text-fig. 10), where not only the differences between one brain and another are exhibited, but also those between the two sides of the same brain. I imagine that the series selected almost exhausts the variations which can occur in this region of the brain. It will have been observed in reading the foregoing remarks that nearly all the sulci of the brain of *Hyrax* are subject to variation—that indeed only the lateral furrow remains constant.

* *Loc. cit.* fig. 171, p. 299.

† *Loc. cit.* fig. 169, p. 298.

Arteries of the base of the Brain.—I figured in the 'Proceedings' of this Society some years since* the chief arteries which form or are derived from the circle of Willis in *Hyrae capensis*. A number of the brains upon which I have just reported show the

Text-fig. 10.



Lateral view of the Sylvian region of eleven brains of *Hyrae capensis*.
Figs. 1, 2, 3, &c. represent the left side. Figs. 1a, 2a, 3a, &c. the right side
Each figure is bounded by the suprasylvian fissure above and the
rhinal fissure below.

cerebral arteries and enable me to amend in some particulars and to confirm in others the figure and description referred to. I have there figured no communication between the basilar artery and

* P. Z. S. 1904, vol. i. p. 187, text-fig. 18.

the right side of the circle of Willis. It is clear, however, that this specimen was so far abnormal; for in nine others (the only ones in which the arteries were visible) both divisions of the basilar artery were plainly present, thus completing the symmetry of the circle of Willis.

I find that as a general rule the basilar artery is undivided upon the medulla, as I have figured it in *Hyrae* *. But in two out of the nine specimens the artery formed a loop, such as I have figured in *Tamandua*, but longer. Such a bifurcation and re-union of the basilar artery is very common among Ungulates. In each case the vertebral artery on either side joins the anterior rhinal artery behind the loop. These arteries mark the end of the medulla oblongata. I may remark that a misinterpretation of the woodcut illustrating the arteries of the base of the brain in *Equus* in Messrs. Chauveau and Arloing's treatise, led me to compare *Hyrae* especially with *Equus* in the posteriorly situated communication of the carotid with the circle of Willis. They are as a matter of fact anteriorly placed in the Horse as in the Rhinoceros †, and posteriorly placed in *Hyrae*. In five examples of *Hyrae* I found that the carotid became continuous with the circle of Willis just opposite to the origin of the posterior cerebral artery. The other specimen examined by me did not show the relations of the artery with great clearness. I mention this matter particularly since it is not dealt with in my original figure of the arterial system of the brain. I find that the arteries at the base of the brain in *Hyrae* differ in another particular, unless indeed I have made an error in my former description. For I find that in several brains the anterior cerebellar artery arises on each side from the bifurcate basilar artery, and not from the latter posteriorly to its bifurcation. In spite, however, of these few additions to the description of the arrangement of the arteries forming the circle of Willis, it remains clear that *Hyrae* comes nearer in respect of these structural peculiarities to the Perissodactyle than to the Artiodactyle section of the Ungulates, a position upon which I ventured to insist in the paper already quoted.

Cæcum and gut of Hyrae dorsalis.—Of this species of *Hyrae* I have recently dissected two examples which permit me to compare certain organs with the corresponding organs in *Hyrae capensis* and *Hyrae syriacus*. In the general subdivisions of the cæcum of *H. dorsalis* I find no differences from those of *H. capensis*. When the cæcum is viewed on the opposite side to that on which the ileum enters it, two muscular bands as in *H. capensis* are seen to traverse the cæcum, forming by their contraction two parallel furrows upon the surface of the cæcum; these ultimately join to form a single muscular band and furrow. The junction is, however, considerably further forward in *Hyrae dorsalis*, at a point in fact corresponding to the end of the first two-thirds of the entire length of the cæcum. Furthermore, while in *H. capensis*

* *Loc. cit.* p. 189, text-fig. 19 b.

† Beddard & Treves, *Trans. Zool. Soc.* vol. xii. pl. xxxvii.

the cæco-colic ligament extends down to the end of the cæcum more or less along the inner of the two muscular bands only, this ligament is much less extensive in *H. dorsalis*. It lies, as in *H. capensis*, upon the outer of the two muscular bands of the cæcum, *i. e.* that on the colic side of the cæcum, but does not extend back even so far as the point where the two bands unite to form a single muscular band.

The cæcum of *H. dorsalis* then, like that of *H. capensis*, shows on the ventral side two longitudinal tæniæ where only one perhaps would have been expected. I take this to mean that the space included between these two muscular bands is the ventral surface of the median chamber of the cæcum, which is so apparent dorsally between the two lateral chambers and is externally divided from them by two muscular bands bearing blood-vessels which are continuous in front with the ileo-colic mesentery. When the cæcum is dilated with fluid, these bands are seen to produce much puckering of both the median and lateral portions of the cæcum. When the cæcum is cut open these three chambers are recognisable, but there are no permanent folds dividing them; the walls of the cæcum can be pressed flat. On the other hand, there are two anterior chambers of the cæcum, right and left, which are divided from the rest of the cæcum by permanent though low folds which cannot be stretched out flat; they are actually valve-like thickenings of the walls of the cæcum. These lie in front of the entrance of the ileum and closely embrace the dilated commencement of the colon, the bands bearing blood-vessels already referred to upon the dorsal side of the posterior region of the cæcum divide them off from the median "chamber" of the posterior region of the cæcum.

I have recapitulated these facts, firstly to show the general resemblance of *H. dorsalis* to *H. capensis* in the form and subdivisions of the cæcum, and secondly to emphasise another difference between the two species. This is the extension backwards of the median dorsal chamber beyond the two lateral chambers, so that it can be seen on the ventral aspect of the cæcum in *H. capensis*. This is not the case with *H. dorsalis*. There are thus two quite distinct differences between the cæca of these two species. The two chambers already referred to which embrace the terminal section of the cæcum or the beginning of the colon, according to the interpretation preferred, are spoken of by Lonsky* as the "mittlere Etage" of the cæcum, lying in fact between the lowest story which forms the blind end of the cæcum and the upper story out of which emerges the colon. I am inclined to consider that this region is potentially double—a meeting of the actual folds which delimit each half would convert each half into a tube—as indeed it appears to be externally. In this case a comparison may be fairly made with the two caecal appendages of the Manatee†. Lonsky has indeed compared the cæcum of

* Jen. Zeitschr. xxxvii. 1903, p. 580.

† Murie, Trans. Z. S. viii. pl. 23, fig. 28; & Beddard, P. Z. S. 1897, p. 50, fig. 3.

Manatus with that of *Hyraux*, but not in regard to the paired outgrowths. He has rather emphasised the median chamber in which they meet, and has compared this with the two chambers of the cæcum of *Hyraux* as I consider them together with the median space common to the two. Lonsky observes that the ileum enters the middle chamber of the cæcum and that it is without an ileo-cæcal valve. The latter statement is certainly not true of *H. dorsalis*, the valve was quite obvious in the two specimens which I have dissected. Furthermore it appeared to me that the ileo-cæcal orifice lay in this species of *Hyraux* in the lower and largest chamber of the cæcum. The raised fold which separates off from this latter subdivision the two diverticula (as I regard them) can be distinctly seen to join the posterior lip of the ileo-cæcal valve, *i. e.* that nearest to the colon. On the other hand, there is undoubtedly on each side a branch of this fold which passes to the other side of the ileo-cæcal orifice. The posterior fold, however, appeared to me to be the most important. The question is obviously a difficult one to be decided. Finally (as regards the alimentary tract) I may remark that the present species, *Hyraux dorsalis*, differs from *H. capensis* and agrees with *H. syriacus* as described by Lonsky, in possessing a longish cæcal appendage of the colon lying between the true cæcum and the paired colic appendages. Nearly up to the very tip of this diverticulum, which is about an inch long, is attached the cæco-colic ligament, the other attachment of which to the cæcum has been already described. Although *Hyraux capensis* does not possess this diverticulum, there is certainly a slight dilatation of the colon where the cæco-colic ligament is fixed. It does not appear to exist in *Hyraux brucei**.

The Testes of Hyraux dorsalis and H. capensis.—In all the specimens of both of these species which I have examined, the testes (which are well known to be invariably intra-abdominal) are partly enveloped by a freely hanging membrane of considerable circumference, of which I can find no description in recent memoirs dealing with this Ungulate, and which therefore is at least not well known. The most recent and most elaborate survey of the genitalia of *Hyraux* (both male and female) known to me is in the memoir of Lonsky already referred to†.

Neither in the text nor in the figures illustrating it‡ does Lonsky refer to the membrane to which I shall presently refer at greater length. This structure has been described and figured by Pallas§, whose description runs as follows:—"Testes . . . et margine libero coronati membranula, seu ala e peritonæo facta et adipe striata, quæ vasa a spermaticis accipit." It is illustrated by a figure|| which does not, however, represent quite accurately the conditions which are observable. The sperm-duct is represented

* Chapman, P. Acad. Philad. 1904, p. 476.

† Jen. Zeitschr. xxxvii. 1903, p. 612 &c.

‡ Loc. cit. pl. 29. figs. 4, 5, 7.

§ Spicilegia Zoologica, Berolini, 1767, Fasc. 2. p. 29.

|| Tab. iii. fig. 11.

as expanding into the freely floating membrane, and thus suggesting unduly the funnel of an oviduct. This almost inclines one to the belief that Pallas had confused the epididymis with the membrane in question, though the phrase quoted above seems to negative this belief. It seems, however, that later writers have not referred to this structure, for the most part at any rate. The classical memoir of Brandt* contains no account of the membranous appendage of the testes, nor is it figured. Indeed, this anatomist has only figured the female organs. Nor is it represented by George† or Chapman‡. In both *Hyrax dorsalis*, and *H. capensis* there is invariably (so far as my experience goes) a loose fold of membrane, depending freely into the body-cavity, of a reddish colour in parts at least, and with an irregular edge, which is attached to each testis. This varies in size in different individuals (at any rate, it varied in two examples of *Hyrax dorsalis*) and is restricted to a less, or expands to be attached to a greater, area of the testes. There are also differences on the two sides of the body.

One of the most recent memoirs dealing with the anatomy of the male organs of the Elephant is that by v. Mojsisovics upon the African Elephant§. He describes "Ein nahezu vollständiger Peritonealüberzug heftet sie [*i. e.* the testis] an die mediale Seite der Niere etwas unterhalb des Hilus. Cuvier vergleicht dieses Aufhängsband der Form nach mit einem Lig. uteri laterale." I do not, however, think that this is anything more than the ligament to which I have referred and which unites testis and kidney in *Hyrax*. The late Dr. Morrison Watson|| says nothing of any such free floating membrane as that which characterises *Hyrax* in the Indian Elephant. But Camper¶ speaks of "La membrane qui les envelope formoit des deux cotés plusieurs franges garnies de longues appendices en forme de petits epiploons." The figure** illustrating this appears to me to be of a structure comparable to the testicular membrane which I here describe in *Hyrax*.

These variations suggest an organ which is no longer functional; and it is in any case difficult to see what can be the actual use in the economy of this floating sheet of membrane. It seems to be quite distinct from the narrow and tightly stretched ligament which joins the testis to the anteriorly lying kidney. It is, in fact, associated with the testis, and not with the kidney. The close association, its reddish colour, and fimbriated edges suggest very much the appearance of and association with the ovary of the oviducal funnel in Marsupials. And it is possible that this structure is really the equivalent of an oviducal funnel persisting in the male. There is, however, another possibility. The

* Mem. Ac. St. Peterb. (7) xiv. 1869.

† Ann. Sci. Nat. (6) i. 1874.

‡ Arch. f. Naturg. 1879, p. 82.

§ P. Acad. Philad. 1904, p. 476.

|| J. Anat. Phys. vii. 1873, p. 60.

¶ Description anatomique d'un Elephant mâle. Paris, 1802, p. 55.

** Loc. cit. pl. v. fig. 1.

membrane in question may correspond to a gubernaculum testis diffusely developed. This, however, appears to be less likely. By many zoologists the Hyrax is regarded as forming with the Elephant a group, Subungulata, lying at the base of the Ungulate series. Recently opinion appears to be veering away from this view of the affinities of the animal. Lonsky, already quoted, sees in the alimentary tract and genitalia "the most resemblance" to the Rodents; while Erich Fischer* holds that the carpus and tarsus are not derivable from a primitive Ungulate such as *Phenacodus*, but since they combine the characters of Rodents and Ungulates are perhaps more to be compared to those of the Tillodontia or primitive Toxodonts. Finally, Assheton† cannot see in the placenta any likeness to that of any Ungulate or Elephant, but compares it on account of its "cumulate" characters to that of the Insectivora, or even to that of the Primates. It is, therefore, not without interest to note that in the characters of the testis *Hyrax* shows a likeness to one of the few other Eutherian Mammals in which the testes are completely abdominal in position throughout life, viz., *Elephas*. Lonsky denies any special resemblance in form, but says nothing of the testicular membrane with which I am at present concerned.

(3) *On the Existence of a new Skeleto-visceral Muscle in the Pygmy Hog, Porcula salvania.*

Among the Mammalia the only skeleto-visceral muscles, *i. e.* muscles which pass from some part of the bony skeleton to some viscus or viscera, are confined, so far as I am aware, to the diaphragm and to muscles in the hyoid region. Nor are such muscles very common among the lower vertebrata. We have the slips of muscle which run from the ribs to the surface of the lung, and the two muscles connecting the windpipe with the skeleton, in Birds; there are certain muscles connecting the vertebral column and the œsophagus and lungs in Frogs; the ventral sheet of muscle reaching the stomach and liver in Crocodiles and the Lizards of the genus *Varanus*; muscles in the mesentery of various Saurians, and the tongue-muscles in all of these animals. These are at least the principal instances of such skeleto-visceral muscles among Reptilia, Amphibia, Crocodilia, and Aves.

It is, therefore, interesting and not without importance to be able to add to this series a quite new muscle of the same kind in the Pygmy Hog, *Sus*, or *Porcula, salvania*. The anatomy of this pig was carefully described by Dr. J. G. Garson some years since in the 'Proceedings' of this Society‡. I cannot find in that account, which is quite comprehensive as regards the viscera, any mention

* Jen. Zeitschr. Bd. xxxvii. 1903, p. 691.

† Phil. Trans. B, vol. 198, 1906.

‡ P. Z. S. 1883, p. 413. This, moreover, is described as the "first part." The second part, dealing with muscles, has not I believe appeared.

of a peculiar muscle arising from the vertebral column in the middle line and running to be inserted on to the œsophagus.

The direction of the muscle is almost transverse, and it arises from the centre of either or both of the seventh and eighth dorsal vertebrae. It lies opposite to the second branch of the azygos vein, which in this animal is developed only upon the left side. A nearer examination of this muscle where it ends upon the œsophagus shows that it is continuous with a distinct and easily separable muscular sheath of the œsophagus. The muscle is so large that it could hardly escape being seen if the thorax of the species were examined by anyone. I imagine, therefore, that the reason why it is not described by Dr. Garson is that he intended to describe it later in the second part of his memoir dealing with the bones, the muscles, and nerves of *Porcula salvania*. After finding this peculiar and very obvious muscle in the Pygmy Hog, I looked for it in some other Suidæ, but so far with negative results. I did *not* find the vertebro-œsophageal muscle in *Dicotyles tajacu*, or in *Phacochoerus æthiopicus*. It was also apparently absent in a young *Sus cristatus*, which completes the list of Suidæ which I have examined up to the present date for this particular structure. Nor has a superficial examination of other mammals shown anything of the kind to be present. I am at least convinced that no such large muscle in the same situation or hard by exists in a large number of mammals. Unfortunately I neglected to note the minute structure of this muscle. I presume, however, from its large size that it consists of striated fibres. I have described in the heading to this section of the present communication to the Society the muscle just described as "new." I believe it to be so. But at the same time something of the kind has long been known to exist at any rate in man.

Thus Prof. Birmingham writes* :—"The longitudinal fibres [*i. e.* of the œsophagus] are often joined by slips of unstriped muscle, or elastic fibres, which spring from various sources, including the left pleura (constant, Cunningham), the bronchi, back of trachea, pericardium, aorta, &c. These slips assist in fixing the œsophagus to the surrounding structures in its passage through the thorax, and have been aptly compared to the tendrils of a climbing plant." It is plain that these slips of muscular tissue also correspond to similar slips often very numerous and closely adjacent which occur in the corresponding and in other situations in the mesenteries of Saurians. A massing of these would produce a muscle like that which I have just described in *Porcula*† *salvania*. This subject, however, evidently requires further study. All that I can say at present is that there are certainly some mammals in which a large vertebro-œsophageal muscle like that of *Porcula salvania* does not exist.

* Textbook of Anatomy; edited by D. J. Cunningham. London & Edinburgh, 1902, p. 991.

† It is true that Dr. Garson saw no reason in view of the structure of the animal for retaining the generic name. I have, however, described a new character which may go towards justifying its retention.

The sheath of muscles derived from this vertebral slip in *Porcula salvania* continues on to, or to the neighbourhood of, the diaphragm. As already mentioned, I neglected to ascertain whether this sheath and the muscular slip from which it is derived were composed of striated fibres. Supposing that they are—the most likely supposition, as I think—it may be of interest to compare this sheath with that of other mammals. In a considerable series of papers the late Mr. Gulliver* recorded a striate sheath to the œsophagus which in man may be regarded merely as a slight extension backwards of the striated fibres of the pharynx, but which is a more important matter in, for example, Rodents and Ungulates. In them the striated layer continues back to the hinder end of the œsophagus. It is possible that this state of affairs is traceable to the attachment of a muscle like that described in *Porcula*, the greater part of which has disappeared in other types, leaving only the œsophageal portion.

(4) *Notes upon the Anatomy of the Prongbuck (Antilocapra americana), and on the Colic Helicine in some Artiodactyles.*

In the most recent paper known to me upon the American Prongbuck Antelope†, Mr. Lyon enumerates the very abundant sources of information respecting the horns of that anomalous Antelope, and in discussing the systematic position of *Antilocapra* refers to Dr. Murie's account of its anatomy in the 'Proceedings' of this Society‡. I believe that this latter paper contains all that is known up to the present time respecting the visceral structures of the animal with which I am concerned in the present communication to the Society. There is thus much less consensus of opinion upon the general anatomy of this Bovine than upon the nature of the horns, concerning which Mr. Lyon refers to no less than 19 separate memoirs or references in larger works. I endeavour in the following pages to supplement Dr. Murie's paper by some notes upon certain organs which he has not described or not fully described.

The *Azygos veins* of *Antilocapra* are on the plan of those of the typical Artiodactyla, meaning in this case, by "typical," the majority. On the left side is the principal vein. This is formed of an azygos which meets a precardinal vein running from before backwards to meet the azygos or postcardinal. The former is not long. The latter is as usual rather long and extends a moderately long way back towards the diaphragm. The point of junction of the two veins and of their connection with the heart is opposite to the fifth rib (there are altogether thirteen pairs of ribs). As is the case with other Artiodactyles, as a rule there are also veins on the right side belonging to the azygos series, and of these there are two which open, the one behind the other, into the precaval

* P. Z. S. 1869, p. 249, and P. Z. S. 1870, p. 283, with other papers quoted.

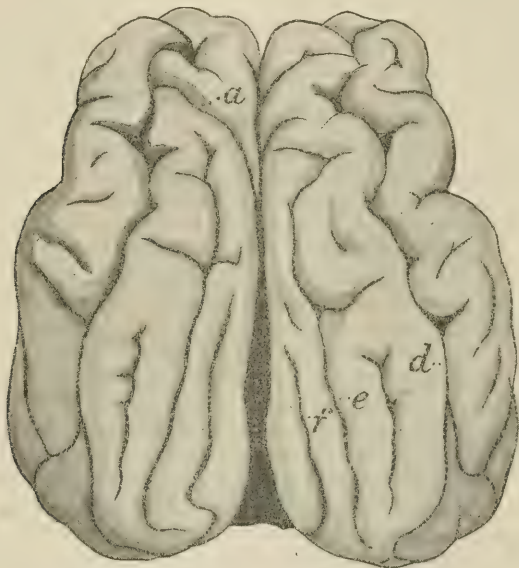
† "Remarks on the Horns and on the Systematic Position of the American Antelope," P. U. S. Nat. Mus. xxxiv. 1908, p. 393.

‡ P. Z. S. 1870, p. 334.

vein. The first of these, which is the superior vertebral vein, supplies the first intercostal space; the next vessel is formed by the union of two twigs which supply the next two intercostal spaces. It will be seen that in detail the azygos system of this Antelope differs from that of other forms. But it is at present perhaps premature to compare the genus in this respect with other Cavicorn or Cervine ruminants.

The Brain.—I believe that the brain of *Antilocapra* has not been described, though a "cast of the cranium" is referred to in

Text-fig. 11.

Brain of adult Prongbuck (*Antilocapra americana*), dorsal view. Nat. size.

a. Coronal sulcus. d. Suprasylvian. e. Lateral sulcus. f. Entolateral sulcus.

the Catalogue of the Museum of the Royal College of Surgeons*. I describe in the present communication a brain of an adult *Antilocapra americana* recently living in the Society's Gardens. The outline of this brain as seen from the dorsal side is remarkable for the squareness of the anterior portion in front of the fissure of Sylvius, as seen in the accompanying figure (text-fig. 11) and as referred to under the description of the brain of *Madoqua* on p. 190.

The *splenial* sulcus is not apparent upon the dorsal surface of the brain; its relations with the crucial sulcus anteriorly seem to me to be remarkable and unlike those of some other Artiodactyles.

* P. 335.

For example, in the brain of *Madoqua phillipsi*, which will be shortly described in the present communication, the splenial sulcus is continuous anteriorly with the crucial sulcus and does not communicate with the coronal sulcus, which sends a branch posteriorly to the middle line. Precisely the same arrangement occurs in the Sheep, as figured by Elliot Smith. On the other hand, in the Pig tribe, as is well known, and as will be also pointed out in the present communication to the Society, the splenial fissure is continued into the coronal. In the Babyrussa there would seem to be a continuation of the splenial into both these fissures. The crucial fissure and the fissure lying behind it, which represents the inner and posterior limb of the sulcus coronalis, are as plainly shown in *Antilocapra* as in *Madoqua* (cf. text-figs. 11 & 16) and in other genera *. The crucial fissure on one side (the right) joins the coronal, and on the other though continuous with the coronal it does not reach the middle line of the brain. The coronal behind is also asymmetrical, but in a different way; on the right the fissure is separated by a bridging convolution from the junction of the coronal and the branch of the suprasylvian. On the left there is complete continuity.

It is this coronal fissure which is continuous with the splenial, and not the crucial as in *Ovis*. The lateral fissure proper, which I take to be the middle one of three lateral fissures, is remarkable for the fact that at the end of its first third (about) there is a strong branch at right angles on the outside, and also some indications of a similar branch at the same spot on the inside, the two together forming a cross branch. The ecto- and entolateral sulci run forwards to nearly as far as this point. The entolateral fissure, it may be observed, does not nearly reach the middle line. The suprasylvian fissure is absolutely continuous with the coronal, as in *Cervus* †. It bifurcates posteriorly in the occipital region into a Y. There are two marked descending furrows, one in front of and one behind the Sylvian. The genual fissure is not continuous with the splenial (intercalary).

In addition to the brain of the adult Prongbuck just described, I have had the opportunity of studying two foetal brains extracted from the mother, but of nearly if not quite full-time. Unfortunately they were both rather damaged at the time, but I have been able satisfactorily to compare certain of the sulci with those of the large brain. The strong branch of the lateral sulcus running at right angles to it, which seems to me to be so characteristic of *Antilocapra*, is quite obvious in both of these brains and on both sides of the brains. I have mentioned particularly the fact that the entolateral sulcus does not reach the middle line of the brain. In one of the foetal brains the relationship was the same; in the other, however, the entolateral sulcus of the left side only did dip over the mesial edge of its hemisphere. As to the continuity of the coronal with the splenial sulcus I can only

* E. g. *Cervus*, Elliot Smith, *loc. cit.* p. 329, fig. 191.

† Holl, Arch. f. Anat. Phys. pl. xviii. fig. 10, & Elliot Smith, *loc. cit.* fig. 191, p. 329.

speak of one of the foetal brains, and in that there certainly was this continuity. Furthermore, on one side of the same brain (the right—I cannot say anything of the left) the crucial sulcus was continuous with the coronal.

Muscular Anatomy.—I have dissected some of the muscles of one of the foetal specimens of *Antilocapra*, and have compared my dissections with the comprehensive account of Ungulate myology of Messrs. Windle & Parsons *. The *latissimus dorsi* cannot be said to be a feeble muscle in this Ungulate. Its origins are, as usual, in common with the trapezius and behind and contiguous to that muscle from the spines of some dorsal vertebrae, from the lumbar fascia covering over the longissimus dorsi and ilio-lumbaris muscles, and from three ribs nearer to their ventral than to their dorsal ends—from the sides of the thorax in fact. A little way down the scapula the muscle diverges from the trapezius and passes under the broad triangular scapular head of the triceps to reach the humerus. Just at this region it gives off a feebly developed *dorso-epitrochlear* branch to the elbow, and is connected with the *teres major*, in common with which it is inserted. Here also the *panniculus carnosus* is attached to the *latissimus*.

The *rhomboidei* are, as is usual in Mammals, two in number and composed of a more superficial and a deeper-lying muscle. The superficial is the more anterior of the two, but only covers the deeper-lying part of the muscle anteriorly. Its fibres are also more antero-posterior in direction than those of the other. The insertion to the edge of the cartilaginous supra-scapula commences in contact with and posteriorly to the *supraspinatus* anteriorly, and posteriorly ends a quarter of an inch or so in front of the posterior commencement of the insertion of the *serratus*. These two muscles, therefore, form a nearly complete semicircle (or rather, semiellipse) of insertion on to the supra-scapula.

The *serratus*, as already mentioned, is quite contiguous anteriorly with the superficial rhomboid and arises from eight ribs, the *latissimus dorsi* immediately following from the three ribs which lie behind those eight. Its insertion on to the scapula is both in front of and behind that of the *rhomboidei*.

The clavicular portion of the *deltoid* forms part of the great Ungulate cephalo-humeral muscle. The spinous portion arises, as in other Ungulates, not only from the spine of the scapula, but also from the fascia covering the *infraspinatus*.

The *subscapularis* is fairly extensive. It arises from and covers the greater part of the ventral surface of the scapula. There is a very small gap left between it and the semicircular insertion of the *serratus* and *rhomboidei*. Anteriorly, however, a portion of the *subscapularis* is somewhat distinct from the rest of the muscle and leaves a tract of bone, not long, between its origin and the insertion of the *rhomboideus*.

The *supraspinatus* extends over on to the ventral surface of

* P. Z. S. 1901, vol. ii. p. 626, and P. Z. S. 1903, vol. ii. p. 261.

the scapula, where it comes into contact with the anterior edge of the subscapularis muscle. It arches over the tendon of origin of the biceps and is muscular at its insertion, with however a glistening tendinous surface.

The *infraspinatus* is distinctly divided at and for some little way in front of its (therefore) double insertion into two layers, of which one overlies the other.

Teres minor is a slender muscle ending in a long flat tendon below the insertion of the spinous part of the deltoid, and therefore considerably below the insertions of the infraspinatus, which are above that of the section of the deltoid referred to.

The *teres major* is a very much larger muscle, flat and strap-shaped, and closely connected with the latissimus dorsi near to insertion.

Biceps.—This muscle is single-headed, as in other Ungulates. The strong tendon of origin seems to me to arise very distinctly from the coracoid process, but also doubtless from the adjacent margin of the glenoid cavity. Low down on the arm and at the end of the insertion of the pectoralis, a stout fibrous band is given off which runs diagonally towards the elbow. This is chiefly connected with the lower end of the pectoralis, but is adherent to the biceps where it crosses it. A little further down and just before its insertion the biceps is connected with a stout tendinous sheet running down the forearm, in the centre of which is a stouter tendon which can be seen to end on the surface of the biceps.

The *brachialis anticus* winds round the humerus in the way that has been described in other Ungulates. Its insertion is remarkable for the fact that it is adherent by a tendon to the stout tendinous plate running down the forearm, which has just been described, in connection with the biceps before its definite insertion on to the ulna.

Triceps.—This muscle consists of at least four very distinct parts, unless it were better to term one of these anconæus. Of these heads the scapular was precisely as described by Windle & Parsons, arising from a large portion of the axillary border of the scapula. When cut across transversely, there were considerable indications of the division of this muscle into two layers, as also noted by those authors. The inner humeral head seems to be peculiar in some respects. It arises below the coracobrachialis and immediately divides into two muscles, of which the posterior is more or less cylindrical in form in the middle and circular in transverse section, and is totally free from any connection with the shaft of the humerus. The larger portion, that lying anterior, has an origin from the humerus for about halfway down the shaft of that bone. When it becomes free it is rejoined by the other slip of the muscle just before mentioned, and the two form a flat tendon at the internal condyle. The external head arises on the opposite side of the humerus and is a broader and strap-shaped muscle. It closely covers the brachialis anticus at its

origin. In addition to these three heads there is a fourth, which is obviously referable to the triceps complex. Its origin is from the lower half of the humerus and its situation is posterior to and between that of the last two heads mentioned. It is divisible into two parallel muscles, which join before their fleshy insertion on to the olecranon to the external side of the rest of the triceps.

Antilocapra has only three extensor muscles the tendons of which are inserted upon the phalanges of the toes, or rather four, of which two become united at the wrist, and may therefore be regarded as a single muscle. In the middle of the metacarpus only three tendons can be seen. Messrs. Windle & Parsons describe as long extensor muscles in the Ungulata the tendons of which are inserted upon the phalanges: (1) Extensor communis digitorum; (2) Extensor minimi digiti; (3) Extensor profundus digitorum, which, however, is described as only occurring in the Elephant and occasionally in Suidæ.

The four muscles in *Antilocapra* have the following origins and insertions:—

(1), (2). Two muscles arise one below (not deep of) the other, and in close contiguity at their origin from the external condyle; the lower head, which is the smaller, also varies, and perhaps may be said to chiefly arise from the shaft of the ulna quite at the commencement of the latter. The two tendons are perfectly distinct until a little way beyond the wrist, when they absolutely join. These two muscles together form, as I presume, the *extensor minimi digiti* (or *extensor digitorum lateralis*).

(3). A thin muscle, arising from the external condyle under cover of the upper part of the extensor minimi digiti, is reinforced by a long slender muscular slip from the ulna, and ends in a tendon which closely accompanies that of the next muscle to be described. The tendon runs between the two toes covered by the intrinsic extensors of the hand and supplies both digits. This tendon with its two branches contrasts with the broad flattened termination of the tendon of the extensor minimi and of the next muscle to be described. The division of the tendon into two is quite low down, in fact at the very end of the cannon-bone. I imagine that this muscle is the *extensor communis digitorum*.

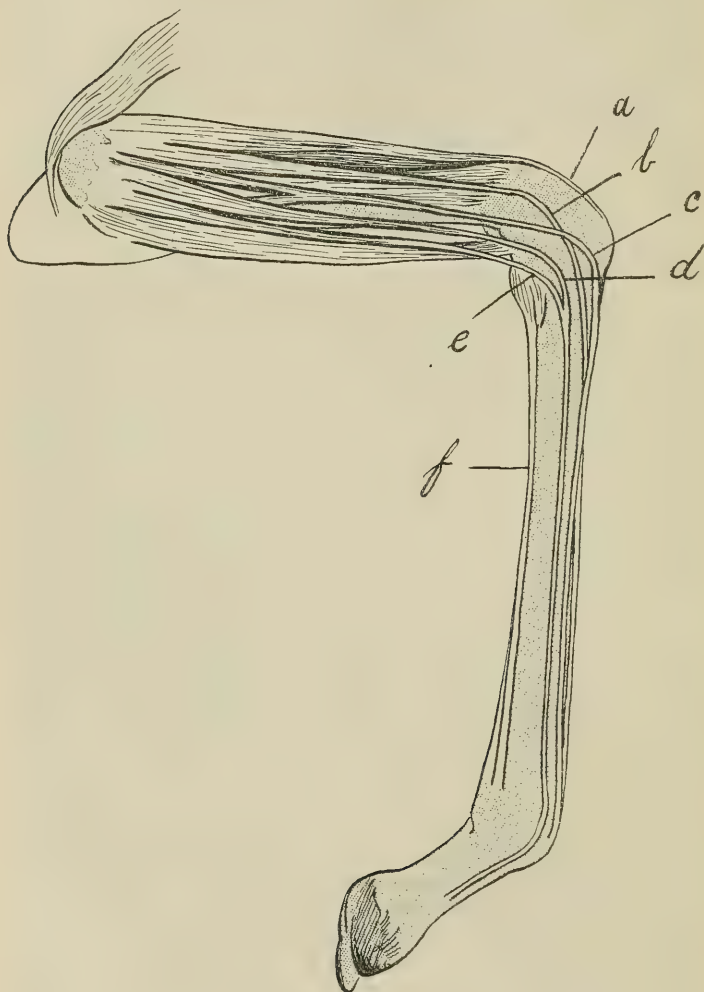
(4). The third (see above), or perhaps fourth, long extensor muscle of the hand of *Antilocapra* arises higher up the humerus, below and in contact with the thick fleshy extensor carpi radialis. Its tendon, which has been already referred to, supplies the medius digit. It has no second head that I could discover. I suppose that this muscle is the equivalent of the *extensor profundus digitorum*, which has been stated in the case of the Pig to be inserted upon the index and medius digits*.

I now pass on to the muscles visible on the extensor side of the forearm before considering the arrangement of the flexors.

* *Fide* Windle & Parsons.

The *extensores carpi radiales longior et brevior* form, as in Ungulates generally, a single muscle, unless indeed the muscle which has just been referred to as the extensor profundus is really the longior. It has the broad strap-shaped tendon described in other forms. A muscle, which I presume to be the *pronator radii teres*,

Text-fig. 12.



Antilocapra americana. Musculature of outside of forearm.

- a.* Extensor carpi radialis. *b.* Extensor profundus digitorum. *c.* Extensor communis digitorum. *d* & *e.* Two tendons just before their junction of the double extensor minimi digiti. *f.* Flexor sublimis.

arises from the ulna and extends over the radius for a long distance towards the wrist.

Finally, on the extensor side of the forearm is to be noted the *extensor carpi ulnaris*.

On the flexor side of the forearm the following muscles are to be seen :—

The first of these, beginning at the lower border, is the *flexor carpi ulnaris*, which is exactly opposite to the extensor carpi ulnaris, and arises from the olecranon as well as from the internal head of the humerus. Its insertion is parallel and contiguous to that of the extensor carpi radialis.

The *flexor sublimis digitorum* arises from the internal head of the humerus and from the surface of and in common with one of the heads of the flexor profundus. It has only one fleshy belly, which ends in a single tendon.

The *flexor profundus digitorum* is also, like the last muscle, rather different from the corresponding muscle in other Bovidae. It has four heads. The first of them is the most superficial, and arises from the internal condyle of the humerus in common with the last muscle, beneath the flexor carpi ulnaris. Two heads of unequal importance arise deep of the last and also from the internal condyle. The fourth head is entirely ulnar in origin, in fact from the olecranon. Its tendon joins that of the two last described heads at about where they join each other. There is not any muscular palmaris longus that I could find, but a very strong tendon flattened in form and much stronger than any of the other tendons of the hand.

The *flexor carpi radialis* presents no peculiarities.

I could find no lumbricales.

There were two short extensors between and below which runs the tendon of the extensor digitorum.

Some of the muscles of the fore limb are illustrated in the accompanying figure (text-fig. 12), and include those in which *Antilocapra* certainly differs from other Ungulates according to the elaborate account given by Messrs. Parsons & Windle of the myology of that group.

In the hind limb, the sheet of muscle and fascia which corresponds to the *gluteus maximus*, *femoro-coccygeus*, *biceps*, and *tensor fasciæ femoris* is attached, as in other Ungulates, to the fascia covering the knee and foreleg for about halfway down. Of this mass I have not been able to recognise all the elements mentioned above as distinct muscular sheets. The tensor fasciæ arising from the ilium in front, is the most conspicuously separate. The others seem to me to form a continuous sheet of muscle, arising from the tuber ischii and the caudal and sacral vertebræ in front. Three *glutei*, besides the maximus, are easy to dissect and separate, and are all attached to the greater tuberosity of the femur, the *glutæus medius* to its free edge, and the other two in front and near to its origin from the femur.

I have no particular remarks to offer with regard to the very

wide *gracilis*, the narrow *sartorius*, and the *semitendinosus* and *semimembranosus*, except that the *semitendinosus* has only one head from the tuber ischii. I am unable to identify with certainty a *preseminembranosus*. The muscle which I term here *semimembranosus* is one muscle arising from the tuber ischii and covering over the adductor which lies deep of it. It is double nowhere along its course, and is inserted along a semicircular line from the end of the femur to the beginning of the tibia, covering over the origin of the *gastrocnemius*. There is no separation at the insertion into two muscles, nor is there any rounded tendon, the insertion being mainly muscular. There is, however, some connection just at the insertion into the extremity of the adductor and also with the head of the *gastrocnemius*. In any case there is nothing like the separation of two fleshy bellies such as are figured by Messrs. Windle & Parsons*.

With regard to the *quadriceps femoris*, I have only to observe that the *vastus internus* is much smaller than the *vastus externus*. The *pyriformis* was perfectly distinct from the *entoglutæus*.

The *tibialis anticus* has but one head of origin, and that is a long flat tendon arising from the external condyle of the femur and passing over the knee in front to form a fleshy belly which ends in a long tendon fanning out at its insertion. A muscle corresponding to the second (tibial) head also exists which ends in a tendon which perforates the tendon of the last and is attached considerably below it, *i. e.*, nearer to the ventral side of the foot.

The *extensor longus digitorum* seems to me to arise only from the fascia between the muscle itself and the femoral head of the *tibialis*. Besides the tendon of this muscle another tendon runs along the anterior face of the metatarsus. The two tendons of the *extensor longus* are separate before the ankle, although they run along the metatarsus closely bound together. The third tendon I refer to the *peroneus quarti digiti*. The *peroneus longus* is also present. No other *peroneals* were found.

I have also dissected the *gastrocnemius* and *soleus*, and find them to be as in the *Bovidæ*. That is to say, that the small and fleshy *soleus* arises from the head of the fibula and joins the outer head of the *gastrocnemius*.

The *plantaris* is remarkable for a relationship to the *gastrocnemius* not commented upon by Messrs. Parsons and Windle. In one specimen that I dissected, there is an intimate connection between the *plantaris* and the outer head of the *gastrocnemius* shortly after their origin. Some of the fibres of the *gastrocnemius* arise from the fascia separating it from the *plantaris*. In fact, the two muscles cannot here be separated by dissection. In the other specimen there was also a connection between the two muscles but rather different in its kind. A slender tendon

* *Loc. cit.* fig. 26, p. 274, S.M. and P.S.M.

left the plantaris and swelling into a slender muscular belly joined the gastrocnemius.

The three *flexors*, viz., *fl. tibialis*, *fl. fibularis*, and *fl. tibialis posticus*, are present, and their tendons were as usual. It is important to note the presence of the last-named muscle, which has been said to be absent in Bovines.

Intestinal Tract.—Dr. Murie* says very little about the intestinal tract of the animal, merely giving the lengths of the several regions and noting the absence of an ilio-cæcal gland. I find the colic spiral to be quite typically ruminant in its characters, and to be perhaps rather large for so small an animal. In one of the two fetuses in which I studied it carefully, the colic spiral was not flat, as it is in some Antelopes with but few coils, but convex. A transverse section through the centre of the coil and including the tract of colon immediately after it has left the cæcum, would cut through the colon fourteen times. The spiral is thus very much longer than—for instance—that of *Madoqua* to be later described. Furthermore, it is to be noted that there is in the fœtus which I examined no marked ansa paracæcalis; the colon where it emerges from the cæcum is not at all bent upon itself in the way so characteristic of many Artiodactyles and Rodents. I could detect no definite ansa paracæcalis; and in this *Antilocapra* agrees with *Tragulid* (see text-fig. 14, p. 184), where there is no loop between the cæcum and the spiral loop.

The cæcum itself has no peculiarities; it has the usual sausage shape and blunt tip of that of other Ruminants. There is some variation among the Ruminants in the degree to which the ileo-cæcal mesentery extends along the cæcum; in *Antilocapra* the membrane extends about halfway along the cæcum. The colon, when the spiral is left, runs at first in a wide loop which is thrown distally into a number of loose folds which are like those of the small intestine in not being permanent. After this a short tract of the colon is attached by membrane to the cæcum; thereafter a short and wide but fixed semicircular loop of colon ends in a short straight rectum. I have examined and can compare with *Antilocapra* as regards some of the facts just mentioned, three species of *Cephalophus*, viz., *C. maxwelli*, *C. melanorrhous*, and *C. dorsalis*. In all of these there is a well-marked ansa paracæcalis. In none of them is there so complex a colic spiral as in *Antilocapra*. Lönnberg has examined several species of *Cephalophus*†, but has not seen *C. dorsalis* which presents differences from *C. maxwelli*. *C. dorsalis* is a larger species than the latter but is differently coloured; it also possesses inguinal glands, which are wanting in both of the other species I have referred to above. While in *C. melanorrhous* and *C. maxwelli* the colic spiral forms a complete circle and about half a circle, it forms two complete circles and a little more in *C. dorsalis*. In a

* P. Z. S. 1870, p. 350.

† Nova Acta Reg. Soc. Upsala, 1903.

transverse section across the coil in the two former species the colon would be cut across eight times; in the case of *Cephalophus dorsalis* ten times. The result is of course that the apex of the spiral is rather different in the two cases. Furthermore, while in *C. melanorrhous* and *C. maxwelli* the ileo-cæcal mesentery is inserted up to the very tip of the cæcum, it falls considerably short of this in *C. dorsalis*.

Dr. Lönnberg* has used a very convenient method of expressing the direction of the various loops of the colic spiral, which I adopt in comparing *Antilocapra* with *Cephalophus* and some other forms (see text-fig. 13). The thick black line indicates the entering colon; the pale line the colon which leaves the coil. The letter X indicates a fixed point in all the figures, *i. e.*, the extremity of the colic spiral, which is of course merely a single loop like that of *Lemur*, &c., and is wrapped within its own curves to form a spiral. It will be noticed that the simplest spiral exhibited among these Antelopes is that of *Madoqua* which will be described later. It forms a complete circle, each limb being approximately equal. The spiral of *Cephalophus dorsalis* is a further advance upon this; the spiral in this Antelope consists of two circles, each limb again being approximately equal. It will be noticed that in both these cases the limb of the spiral, which is continuous with the cæcal side of the colon, ends on the same side of the spine as that on which the cæcum lies, and, furthermore, that the number of the loops of the entering and outgoing colon are equal, *i. e.*, three of each in *Madoqua* and five of each in *Cephalophus dorsalis*.

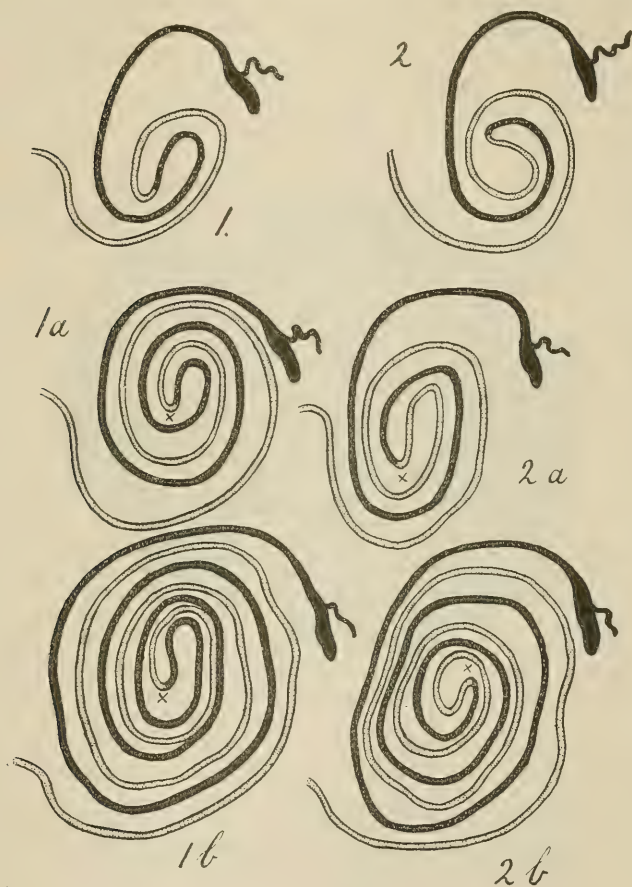
Tragulus stanleyanus, *Cephalophus maxwelli*, and *Antilocapra* form another and a parallel series of ascending complexity. The first-named is on the same level as *Madoqua*. The spiral has only one turn. But the arrangement of the loops is different.

It happens that in *Tragulus stanleyanus* the end of the spiral is directed away from the cæcal side of the spiral, *i. e.*, transversely to the antero-posterior axis of the spiral and to the direction of the terminal loop in the other types already described. It will be seen, however, that if the spiral be increased by half a turn so that the axis of the end of the spiral be made to coincide with that of the other types, the limb of the terminal part of the spiral which lies on the cæcal side of the spiral is not a part of the entering coil of intestine as in *Madoqua* and *Cephalophus dorsalis*, but of the outgoing coil. In *Cephalophus maxwelli* the spiral is more complex, *i. e.* larger, but there is precisely the same relative position of the entering and outgoing limb of the spiral as in *Tragulus*. So finally in *Antilocapra*, which belongs to this same series. Here, however, the tip of the spiral is directed upwards; but if this be altered so as to make the spiral of the same length as in *Cephalophus maxwelli*, it will be seen that the limb of the spiral which forms the cæcal side of the

* Zoologiska Studier tillägnade Prof. T. Tullberg. Uppsala, 1907, p. 248.

terminal portion is the outgoing spiral, precisely as in *Cephalophus maxwelli*. It is not at all surprising—if the facts be properly considered—to find that *Cephalophus dorsalis* and *C. maxwelli* are not near akin in the nature of their colic spirals. The

Text-fig. 13.



The colic helicine in various Artiodactyles, arranged in two series, *i. e.* 1, 1a, 1b, and 2, 2a, 2b. The caecum is represented to the right and the ingoing limb of the spiral is black. The outgoing limb of the spiral is left uncoloured.

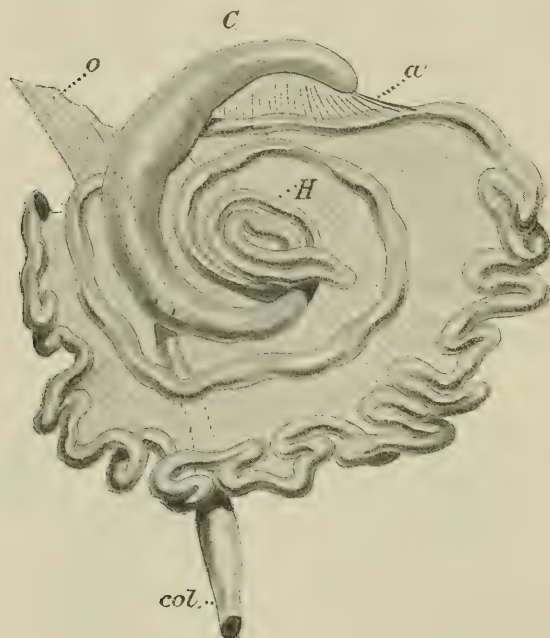
1. *Madoqua phillipsi*. 1a. *Cephalophus dorsalis*. 1b. *Moschus moschiferus*.
2. *Tragulus stanleyanus*. 2a. *Cephalophus maxwelli*. 2b. *Antilocapra americana*.

differences in external characters appear to me to be quite as great as those which distinguish certain other genera of Antelope,

and even greater than those which have been used in a few cases. The internal difference only confirms the value of these characters.

The spirals described in the foregoing paragraphs are committed—so to speak—to one of the two series of right-handed spirals. There is no common basal form from which might arise either type of spiral. Whether such exists among the Artiodactyla remains to be seen. It is important to notice that this does not occur in the case of the simplest spiral known in that

Text-fig. 14.



Caecum, colic helicine, and adjacent parts of the gut of *Tragulus stanleyanus*.

α. Front edge of caeco-duodenal ligament. C. Caecum. col. End of colon or beginning of rectum. H. Colic helicine. O. Omentum.

subdivision of the Ungulata, viz., that of the Chevrotains. It does not thus seem likely that such a spiral will be found in any genus which has not been up to the present examined. There is no doubt, for instance, that the Pig tribe does not help us in this matter in the least. For in most of them at any rate, and probably in all, the colic spiral is very complex and specialised, and offers no hints of the primitive condition. This applies to the Peccary as well as to the more specialised pigs. Nor do the

remaining subdivisions of the Ungulates help us in this search. In neither *Hyrax* nor *Elephas* are there any beginnings of the spiral. It is true that the simple colic loop of the Perissodactyles (found in all the families of Perissodactyla) may be regarded as the progenitor of the spiral; but this is going too far back in the evolution of the spiral. What is wanted is a simple spiral of a negative character which with further growth might evolve into either type. Now it is interesting to find that this form of spiral—precisely what is wanted to serve as a starting point—is to be seen in those Lemurs with a simple colic spiral, i. e., *Galago**, *Loris*, *Perodicticus*, and *Nycticebus*. It will be seen from an inspection of the figure that this simple spiral can be easily regarded as a three quarters of a circle spiral with the apex of the spiral pointing upwards, and of course with the outer limb of the descending part of the colon turned towards the cæcum. On the other hand, it may be regarded as a commencing spiral of half a turn with the apex pointing downwards. In this case it obviously belongs to the other series, for if the spiral were continued so that the apex pointed upwards, the limb forming the apex and nearest to the cæcum would be that of the inner limb of the loop. It is perfectly clear, therefore, that a growth of this rudimentary spiral could produce either of the two types of Artiodactyle spiral with which I am concerned in the present communication. This is of course not tantamount to insisting upon any close relationship between the Ungulates or the Artiodactyle Ungulates and the Lemuroidea†. But it is at least important to note that while the only widely distributed sub-families of the Lemuroidea have preserved without variation an archaic and indifferent form of spiral, the most archaic Artiodactyles have not the simplest form of spiral conceivable. So far, therefore, it would appear as if the colic spiral as such had been inherited by the Artiodactyles. It is, of course, not at all certain that the single loop of the Perissodactyle Ungulates is the homologue of the Artiodactyle spiral; it may represent the ansa paracæcalis of the latter.

The facts detailed under the above descriptions of the anatomy of *Antilocapra* may be supplemented by some account of the intestinal tract in other Artiodactyles which I have had recently the opportunity of examining at the Prosectorium. Among those the most interesting perhaps is that of the Musk Deer (*Moschus moschiferus*)‡. The viscera of this animal, including the alimentary tract, have been described by Sir W. H. Flower§ and Prof. Garrod||. The cæcum is figured by Flower, but the colon is not specially described. A footnote adds that in

* For non-diagrammatic figure see Beddard, P. Z. S. 1908, p. 578, fig. 114.

† Moreover, the apparently similar colic spiral found in certain Rodents (*Hydrochærus*, *Dasyprocta*, and *Cælogenys*) requires further consideration from this point of view.

‡ A female dissected Dec. 21, 1908.

§ P. Z. S. 1875, p. 159.

|| P. Z. S. 1877, p. 287.

the Pudu Deer (*Pudua humilis*), of which a specimen was dissected at the same time by Sir W. H. Flower for the purpose of comparing with *Moschus*, a deer of about the same size, "the colon . . . forms a very simple helicine coil, composed of two complete circles in one direction and of two in the other"*. It is not clear whether it is to be inferred that *Moschus* agrees. In any case, Garrod describes the colic spiral as having three and a half double turns. This statement is approximately correct, as

Text-fig. 15.



Cæcum, colic helicine, and adjacent parts of the gut of *Moschus moschiferus*.

p. Ansa paracæcalis. Other lettering as in text-fig. 14.

will be shown by the annexed figure (text-fig. 15), which gives the same number of coils as has the spiral of *Antilocapra*. The termination of the spiral, however, points downwards, in which *Moschus* disagrees with *Antilocapra*. Nevertheless, it belongs to the same series as that which commences with *Madoqua* (see p. 183). With regard to the ileo-cæcal ligament I confirm Sir W. H. Flower that it is not attached up to the very end of the

* *Loc. cit.* p. 171.

cæcum. It is important to note that this character is apparently a constant one, which I have used above (p. 181) in distinguishing other Antelopes. The ansa paracæcalis of *Moschus* is not dealt with by either Flower or Garrod. It is remarkable in that it is bent upon itself four times to form a small spiral, which is quite as conspicuous a spiral as is that of the Lemurine subfamilies Galaginæ and Lorisinæ, and may even, quite possibly, really be the equivalent of that colic loop—the true ansa coli dextra of the Rodents being in that case absent from the Lemurs.

In *Gazella rufifrons* (a female) the ansa paracæcalis is roughly of the shape of the letter “m.” That is to say, it consists of two parallel loops. Immediately after the ansa paracæcalis the colon diminishes suddenly in calibre, and enters the region of the colic spiral or ansa coli dextra. This is a comparatively simple coil. It is only a little more complicated than that of *Madoqua* described on page 189. Cut right across, the colon would be divided seven times, counting the straight tracts which enter and which leave the coil. As usual, the small intestine is festooned along the colon after the colic spiral. The colon in this region passes almost completely round the circumference of the abdominal cavity, and forms nowhere any special loops. The duodenum where it turns upon itself is fixed, as in other Antelopes, to the colon itself, and not to the mesocolon.

With regard to the colic spiral, it is to be noted that it belongs to the type of *Cephalophus maxwelli*. But the loops do not form a regular watchspring as in those Artiodactyles already considered. For the terminal loop of the spiral does not lie entirely within the coil but extends beyond it.

Dr. Lönnberg comments upon the remarkable colic spiral of the Musk-Ox*. In addition to the spiral coil there is a separate loop formed by the outgoing limb of the spiral, as is depicted in his figure. It seems to me that this state of affairs is comparable to the presence in so many Rodents of two ansæ coli, the dextra and sinistra. The two are close together in Squirrels, for example. If one of these—and they are frequently of different sizes—were converted into a spiral, we should have a condition produced which would be precisely like the Musk-Ox. For the lengthening of the one loop—already the longer of the two—to form a spiral would bring it about that the shorter ansa, remaining a simple tubular loop, would be affixed to the back or to the front of the spiral, as is actually the case in the Musk-Ox. There is, however, no need to theorise; for the Rodent *Dasyprocta punctata* shows exactly the same conditions as those met with in the Musk-Ox. In this species† there is a short spiral and also a simple loop closely affixed to it. I take it that this is a simple form of the complex spiral and associated loop found in the Musk-Ox.

* But only in one specimen out of two; the other showed a single spiral only.

† P. Z. S. 1900, p. 152, fig. 7.

(5) *Some Notes upon the Anatomy of Madoqua phillipsi.*

A dissection of an example of this small Antelope enables me to make a contribution to the knowledge of the structure of the Cavicorn Ungulates, for I believe that we have at present no information as to the anatomy of this particular genus of Antelopes, beyond the notes contained in Lönnberg's paper already referred to.

The example which I examined was a female. The usual four teats were present and also as usual the anterior pair were much further away from each other than the pair lying behind them. There was no trace that I could see of the inguinal glands, and, indeed, the inguinal region, instead of being bare, was particularly well covered with long hair. I have notes upon some of the organs, and I naturally paid special attention to those structures which are known to vary in these animals.

As to the *Vascular System* I found that the heart shows the "moderator band" so frequently found in running animals—birds as well as mammals*. It was a considerable fleshy column connecting together the free and septal walls of the right ventricle. The postcaval vein was typical in its arrangement, *i. e.* the vein lay postrenally to the right of the aorta. The azygos had the following structure:—

The general plan is like that of other Artiodactyles. That is to say, the right azygos is much less important than the left. The latter opens moreover, as is usual, directly into the heart, but it consists of two portions, an anterior and a posterior. They unite just opposite to the transversely running vessel which is formed by their union and debouches into the heart. There is thus, as I may point out, a remnant of the left anterior cardinal, which I presume the anterior branch of the left azygos to represent. This fact in the structure of the azygos of *Madoqua* is furthermore of some systematic interest. For, as I have discovered† in *Rhaphicerus* and *Ourebia*, the arrangement of the veins bringing back blood from the dorsal parietes on the left is quite like that which has just been described in *Madoqua*. Now these three genera have been placed in the same subfamily Neotraginæ. This additional structural likeness justifies still further this placing. The right azygos of *Madoqua* is but feebly developed and brings back blood from only two or three intercostal spaces.

In the *intestinal tract* of Antelopes it is the colon which shows the principal differences. I have therefore made careful notes upon certain points in the structure of that part of the gut in *Madoqua phillipsi*. The *cæcum* is long and like that of other Antelopes in its blunt ending without any diminution of calibre. The *ileum* enters it at an acute angle and is attached to it by mesentery which extends a long way towards the tip of

* To which particular attention was called by the late Prof. Rolleston.

† "On the Azygos Vein in the Mammalia," P. Z. S. 1907, pp. 184, 185.

the cæcum. The *colon* as it leaves the cæcum shows hardly any trace of the paracæcal flexure so common in these animals. There is practically no twisted section of colon at this point. Furthermore, the *colic spiral* is very much reduced, a fact which one naturally associates with the small size of the animal. It is in fact, as the accompanying text-figure shows (text-fig. 13, p. 183), no more complicated than in the Lorisine Lemurs*, which show the simplest colic spiral known to me. A transverse section across this spiral would in fact only divide the colon five times.

This of course recalls the diminutive spiral of the Chevrotains described by Milne-Edwards† and more recently by Mitchell‡. It is to be noted, however, that the spiral in *Tragulius* (see text-fig. 14, p. 184) is rather different from that of *Madoqua*. For in the latter the spiral is flat, and is separated from the cæcum by the ileum to which it is attached by mesentery, just as the ileum in its turn is attached to the cæcum by a band of mesentery. In *Tragulius* the small spiral is fixed on to the cæcum near to its colic end. It appears to me possible that this spiral in *Tragulius* is not the precise equivalent of that of other Artiodactyles, but is the ansa paracæcalis which tends to show a spiral form in many. For example, in the small Antelope *Cephalophus abyssinicus*, of which I have lately dissected an example, the ansa paracæcalis was much more conspicuous and complicated than that of *Madoqua* and tended towards a spiral arrangement; so too with *Moschus* described and figured above. It may also be that the distinctly spiral commencement of the ansa paracæcalis in *Hyrax*§ is referable to the same category, as is also that of many Rodents.

There is, however, some variation in the colic spiral of Ruminants which may be a question of age or of actual variation. I have pointed out that in the Rodent *Hydrochærus*|| the younger individuals have a rudimentary spiral which later becomes large. I have examined this spiral in two examples of the Antelope *Tragelaphus scriptus*, both females. In one specimen the coils were hardly more complex than in *Madoqua*. The colon consisted in this region of four loops each consisting of two limbs, so that a transverse section across this region of the gut would divide the colon eight times. On the other hand, the second specimen had a more complex colic spiral.

I may observe that the close connection of the small intestine with the colon—for the former gut is attached by mesentery to the colon for some distance after the colon has emerged from the colic spiral—is a feature often (? always) found among Artiodactyles; it is paralleled in a remarkable way in the Beaver, another fact illustrative of the numerous structural resemblances between the Rodents and Ungulates.

* Beddard, P. Z. S. 1908, p. 578, and literature therein cited.

† Ann. Sci. Nat. 1864.

‡ Trans. Zool. Soc. vol. xvii. p. 472, fig. 19.

§ P. Z. S. 1908, p. 532.

|| P. Z. S. 1908, p. 537.

Dr. Lönnberg has specially devoted himself to the intestinal tract (and other features in the anatomy) of the Artiodactyles*. As these animals are comparatively little known in the anatomy of their soft parts, I do not hesitate to set down some further facts as a contribution to our gradually increasing knowledge of the group, which may prove to be distinctive not of the particular species now under consideration but of the group generally. In *Madoqua*, as in *Cephalophus abyssinicus*, the end of the duodenal loop is not fixed by the ligamentum cavo-duodenale to the post-caval vein or to the mesocolon, but to the ventral surface of the colon itself.

Some of the recto-duodenal ligamentum strays over on to the adjacent right kidney. I could find no definite hepato-renal ligament. But the right extremity of the liver was attached to the parietes by a well-marked ligament. I may remark also that in *Cephalophus abyssinicus* the duodenum was attached to the rectum itself in precisely the same way by a ligament, and that there was also the same attachment to the right kidney. The left kidney was situated a long way below the right kidney, there being a considerable distance between the posterior end of the right kidney and the anterior end of the left kidney. The spleen of *Madoqua* had the more or less circular contour of this "gland" in some other Ruminants. It was as firmly fixed to the stomach throughout as in other Ruminants. There was in fact no free gastrosplenic omentum.

The *Brain* of *Madoqua phillipsi* is not known, so far as I am aware, and will serve to illustrate the brain characteristics of a small Antelope with the sulci in a simple condition. It may be compared with that of *Antilocapra*, which I also figure in the present communication. The general outline seems to me to be remarkable for the square outline and termination anteriorly of the portion of the brain lying in front of the Sylvian fissure. This form of brain is still more marked in the Pronghorn, which I have dealt with on a previous page. Secondly, as will be seen in the drawing of the dorsal surface submitted herewith (text-fig. 16), the corpora quadrigemina are partially visible, which is at least unusual among the Ungulata. The third obvious peculiarity, also to be seen in the same dorsal view, is the exposure of the splenial sulcus which runs on each side a curved course at some little distance from the median fissure of the brain. The exposure of this fissure is not unknown in other Artiodactyles—it occurs, for instance, in *Tragulus*†, *Dorcatherium*, *Moschus*, *Cervulus*—but it must not be confused with an entolateral sulcus, such as occurs in *Cervus dama*‡, and which at first sight might be confused with it. Its continuation with the crucial anteriorly

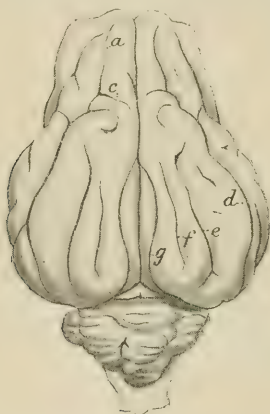
* Nova Acta Reg. Soc. Upsala, 1903; K. Vet.-Ak. Handl. 1901; P. Z. S. 1900, p. 142; and in Zoologiska Studier tillägnade Professor T. Tullberg, 1907, p. 237.

† See Cat. Physiol. Series, Roy. Coll. Surgeons, Vol. ii. 2nd ed., 1902, p. 323, p. 324, p. 325 fig. 187, p. 327.

‡ *Ibid.* p. 329, fig. 191.

shows that in *Madoqua* the fissure in question is really a splenial. Dr. Elliot Smith has remarked* that "the position of this sulcus in the Ungulata seems to be determined largely by the size of the hemispheres," it being visible above in *Tragulids* and not in *Cervus*. So far as *Madoqua* is concerned this generalisation would seem to be true of the Cavicornia as well as of the other Ruminants. The brain of the Sheep has been so often described and figured† that it may be well regarded as a convenient basis of comparison for other hollow-horned Ruminants. There are in *Madoqua*, as in *Ovis*, three lateral fissures of which I identify the middle one and the longest as the lateral, the other two being ecto- and ento-lateral respectively. The lateral bends outwards anteriorly, but does not end in any other fissure.

Text-fig. 16.

Brain of *Madoqua phillipsi*, dorsal view. Natural size.

- a. Coronal sulcus. c. Inner branch of the same. d. Suprasylvian sulcus.
e. Lateral sulcus. f. Entolateral sulcus. g. Splenial sulcus.

The *suprasylvian* fissure is the same on the two sides of the body and consists of precisely the same elements in the Sheep, excepting that I did not find the fissure lettered by Holl‡ "rdss" and represented in the drawing given by Elliot Smith not far behind the Sylvian fissure, but not lettered. The suprasylvian fissure, however, bifurcates posteriorly in a V-shaped fashion as indicated by Holl in *Ovis*; but in *Madoqua* the two limbs are longer, the downwards directed limb running parallel with the sulcus obliquus. The anteriorly situated "inferior" branch of the suprasylvian joins the sulcus coronalis.

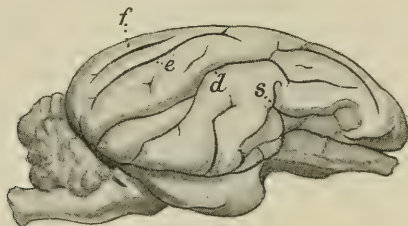
* *Ibid.* p. 326.

† Most recently by Elliot Smith (*loc. cit.* p. 340, figs. 194, 195, 196) and Holl, *Arch. f. Anat.* 1900, pl. xviii. figs. 7, 8, 9.

‡ *Loc. cit.* pl. xviii. fig. 7.

The *Sylvian* fissure in the usual Artiodactyle fashion starts from the edge of the depressed gyrus arcuatus. On one side of the body it is short and runs in a straight course dorsally, being just hooked over anteriorly at the summit. On the other side it is shorter still. There is nothing particular to say of the anterior and posterior ectosylvians.

Text-fig. 17.

Brain of *Madoqua phillipsi*, lateral view. Natural size.

s. Sylvian fissure. Other letters as in text-fig. 16.

The *coronal* sulcus, whose course on either side is straight and parallel with the median sulcus, sends a branch inwards at its posterior end as in other Artiodactyles. This branch, however, does not reach the middle line of the brain on either side. In front of this the gyrus lying between the median sulcus of the hemispheres and the coronal sulcus is indented by the emergence of the splenial sulcus, this indentation being, as I presume, the equivalent of the *crucial* sulcus in other Artiodactyles such as *Ovis**.

(6) *The Brain of Babyrussa alfurus.*

Although the brain of this Suid has been already described by Vrolik †, the description and figures were published a great many years ago and, moreover, do not agree in every detail with the specimens which I have myself had the opportunity of studying. I have examined carefully the brains of two examples of *Babyrussa alfurus* which have died in the Society's Gardens during the last four years ‡, one of which has been drawn for me by Mr. W. S. Berridge, F.Z.S. and is represented in the accompanying text-figure (text-fig. 18, p. 194). The animal was a female. The length of the hemispheres in a straight line is 82 mm., the greatest diameter of the brain 62 mm. I have compared this brain with

* Elliot Smith, *loc. cit.* fig. 195, p. 340.

† Vrolik in N. Verhand. Nederl. Inst. Amsterdam, vol. x. 1844, p. 207. The paper is written in French. The brain is figured in dorsal and ventral views and in section.

‡ The first died June 29th, 1905, the second Jan. 6th, 1908.

specimens of *Sus cristatus* and *Dicotyles tajaçu*, of both of which brains exist in the collection at the Prosectorium.

The coronal sulci are much more obliquely set than in either *Sus* or *Dicotyles*, especially more so than in *Dicotyles*, where the furrows in question, save just where they dip into the middle line, are straight and parallel with the long axis of the brain.

The brain of *Babyrussa* in fact agrees in this particular with that of *Phacochoerus æthiopicus* figured by Elliot Smith *. Not so, however, in their proportionate length; for while in *Phacochoerus*—judging from the figure already referred to—the coronal suture of each side is very nearly half the length of the brain, the length of each of these sulci in *Babyrussa* is 37 mm., measured from the anterior end of the brain to the point where they meet in the middle line of the brain; the rest of the brain measures about 55 mm. These measurements are taken along the curvature of the brain, and are therefore in excess of that just given of the length of the hemispheres.

In *Dicotyles tajaçu* the proportions are reversed, the anterior part of the brain to the posterior end of the coronal sulci is actually longer than the rest of the hemispheres. In *Sus*, however, the proportions would appear to be very much as in *Babyrussa*, and probably by making allowances for the curvature not measurable in the figure quoted, *Phacochoerus* is not very different. Elliot Smith agrees with Garrod † in regarding as distinctive of the Pig tribe the blending of the coronal and intercalary (or splenial) sulci as compared with other Artiodactyles.

The intercalary or splenial sulcus in *Babyrussa* (which obviously suggests—if it be not comparable to—the callosal-marginal of Apes) is continuous with the genual sulcus in front, as in *Sus* and *Dicotyles*. It is also continuous with the coronal, bifurcating, in fact, as it were anteriorly to form the coronal and genual. In this *Babyrussa* of course agrees with other Pigs, as has been already mentioned. It does not, however, agree with an example of *Dicotyles tajaçu* which I have in my possession. I am not quite able to understand precisely what the late Prof. Garrod meant when he wrote concerning the splenial fissure of *Dicotyles* as follows ‡:—"There is one upward branch of the splenial fissure which joins § the fissura coronalis, and is not a continuation of it, as in *Sus*." Dr. Elliot Smith in dealing with the brain of the same species repeats Garrod's word "joined." I find in the only brain which I have examined no communication whatever between "the cingular arc of fused calcarine, intercalary and genual sulci" and the coronal sulcus on either side of the body. A bridging convolution occupies the place where this fissure would otherwise lie. But if the coronal sulcus were continued back to join the

* Cat. Physiol. Series, Roy. Coll. Surgeons, vol. ii. 2nd ed. 1902, p. 316, fig. 182.

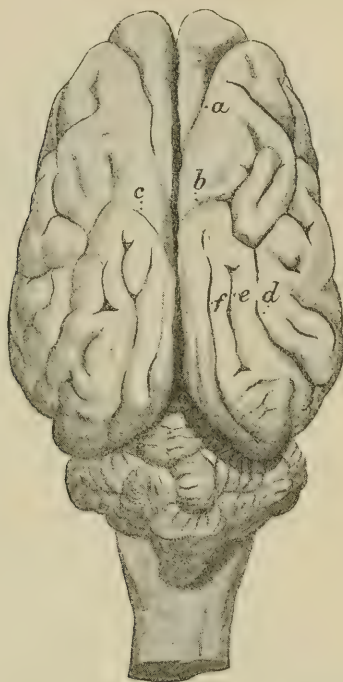
† "On the Brain of Hippopotamus," Trans. Zool. Soc. xi. 1880, p. 13.

‡ Loc. cit. p. 14.

§ The italics are Mr. Garrod's.

splénial (and the gap separating them is but small) there would be no difference in the mode of their connection from that shown in the brain of the *Babyrussa*. There would be a similar appearance of the bifurcation of the splénial that has been referred to.

Text-fig. 18.

Brain of *Babyrussa alfurus*, dorsal view. Three-quarters natural size.

a. Coronal sulcus. *b, c.* Right and left branches of splénial. *d.* Suprasylvian sulcus. *e.* Lateral sulcus. *f.* Entolateral sulcus.

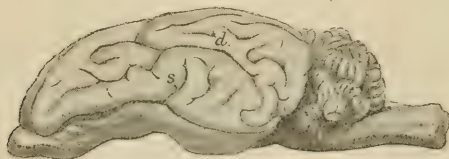
Neither Mr. Garrod nor Dr. Elliot Smith mentions the interesting fact that the convolution lying between the splénial fissure and the corpus callosum (*i. e.* the hippocampal gyrus?) appears on the surface of the brain and is—posteriorly at any rate—not much depressed below the level of adjoining regions of the brain in the Peccary, while it is completely concealed in the *Babyrussa* as, in *Sus*, and apparently in *Phacocharus*. This arrangement is seen in other Ungulates besides *Dicotyles*. In *Babyrussa* the splénial gives rise to another fissure lying behind the oblique furrow which joins it with the superficially running coronal. This is

also well known to occur in *Sus*. But in the specimen of *S. cristatus* which I examined the fissure did not reach the splenial on either side. It may be that this fissure is the real equivalent of what I have described above in *Dicotyles* as the corono-splenial junction. The fissure mentioned by Garrod as the equivalent of the latter does not, however, exist in my specimen.

In any case it is clear that *Babyrussa* agrees with the Old World Pigs, and differs from *Dicotyles*, in the shorter and more obliquely running coronal fissures.

The lateral fissure of *Babyrussa* is less oblique in direction than that of *Sus*, where the two furrows converge greatly anteriorly. There is a well-marked entolateral fissure, and indeed on the right side of one of my two specimens a second entolateral within the first. There is, furthermore, in *Babyrussa* as in *Sus* an ectolateral fissure, which is wanting—as is also the entolateral—in *Phacochoerus** and in *Dicotyles*. In both specimens of the brain of the *Babyrussa* which I possess the ectolateral fissure tends to be rather imperfect, being interrupted along its course by bridging convolutions, and is better developed anteriorly than posteriorly.

Text-fig. 19.



Brain of *Babyrussa alfurus*, lateral view. One-half natural size.

s. Sylvian fissure. d. Suprasylvian.

In *Sus*, on the other hand†, the posterior part of this sulcus is the most clearly marked, as was the case on one side (the right) of one of the *Babyrussa* brains. It is to be noted that this ectolateral sulcus gives off many transverse branchlets in *Babyrussa* as in *Sus*; it is these small transverse furrows only which are visible in *Dicotyles*.

The *suprasylvian* fissure is much like that of *Sus*; and I could see no variations of moment in the two brains of *Babyrussa* nor on the two sides of each brain. The fissure curves round posteriorly towards the ventral surface of the brain, this part corresponding, according to Garrod, with the descending limb of the same fissure in other Artiodactyles. I may remark that *Babyrussa* also agrees with the Wild Swine (*Sus cristatus*) in possessing a small descending limb of the *infrasyllian* in front of

* Elliot Smith, Cat. Roy. Coll. Surgeons, t. c. fig. 182, p. 316.

Owen, 'The Anatomy of Vertebrates,' vol. iii. 1868, p. 123, fig. 104.

the ascending limb of the same, which, as already described, is connected with the splenial. I do not find this fissure in *Dicotyles*.

It does not seem to me that there can be any doubt as to what is to be regarded as the *Sylvian* fissure in *Babyrussa*. Both specimens agree entirely in the position of the fissure which I thus identify; the only differences were slight ones of length and direction of curvatures. I consider as *Sylvian* the fissure which arises, as shown in the accompanying figure (text-fig. 19, p. 195), from the point where the nonpallial portion of the hemisphere is widest, where the rhinal fissure, that is to say, is most convex towards the pallium. But I am not to be understood to deny that this may be a 'pseudo-sylvian' fissure formed by the meeting of two lips over a true *Sylvian* fissure. Deep down between the opercula an island of Reil is visible, precisely as Dr. Garson has figured* in the Pygmy Hog (*Sus salvania*). The figures of the brain of the *Babyrussa* which are appended to this paper show, in fact, that the characters of the brain are those of other *Suidæ*, and that the divergences from the prevailing pattern in that group are only slight, and not at all in the direction of the New World *Dicotyles*, nor of the remaining allied family, that of the *Hippopotamidæ*.

Résumé of New Facts.

The following are the principal new facts contained in the foregoing pages and stated as briefly as possible, with references to the pages where the full description will be found.

- (1) The Himalayan Tapir (*Tapirus indicus* or *malayanus*), like the two species of Elephant, has a pleural cavity which is mainly obliterated by the formation of a dense network of strands of connective tissue uniting the two layers of the pleura. (See p. 161.)
- (2) *Hyrax dorsalis* like *H. syriaca* (described by Lonsky) has a third cæcum about an inch long lying between the unpaired and the paired cæca. The orifice of the ileum into the unpaired cæcum has, unlike what is found in *H. syriaca*, a circular valve. There are specific differences between *H. dorsalis* and *H. capensis* in the cæcum. (See p. 166.)
- (3) The azygos vein in *Hyrax capensis* is, as a rule, confined to the right side of the body. An additional vein on the left side is rare. (See p. 162.)
- (4) The sulci of the brain of *Hyrax capensis*† show considerable variation. This is especially noticeable in the *Sylvian* and the pre- and post-*Sylvian*. (See p. 163.)
- (5) *Hyrax* agrees with *Elephas* in possessing a free fold of peritoneum of considerable dimensions attached to each testis

* *Loc. cit.* (on p. 170).

† This is not an entirely new fact, I extend the data of Dr. Elliot Smith.

and floating in the abdominal cavity, the homology of which is doubtful. (See p. 168.)

- (6) The posterior region of the œsophagus in *Sus* (*Porcula salvania*) is covered by a sheet of muscle which arises as a stout muscular slip from the vertebral column from the centrum of the 8th or a closely neighbouring vertebra. This muscle has not been met with in other mammals, but may correspond to minute fascicles which in man bind down the œsophagus to adjacent membranes massed into one large muscle. (See p. 170.)
- (7) The musculature of *Antilocapra americana* shows certain differences from that of other Bovines in the extensors and flexors of the arm and leg. (See p. 175.)
- (8) The colic helicines of *Antilocapra*, *Cephalophus*, *Madoqua*, *Moschus*, *Gazella*, and *Tragulus* are shown to be referable to two categories according to whether the emergent spiral limb of the colon lies to the right or to the left of the entering spiral. Even the two simplest spirals known among Artiodactyles, *i. e.* those of *Madoqua* and *Tragulus*, conform to the one or to the other plan. (See p. 182.)
- (9) Although two species alleged to be of the same genus, viz. *Cephalophus dorsalis* and *C. maxwelli*, show different spirals, it is by no means certain that these two species are rightly referred to one and the same genus. (See p. 181.)
- (10) In no Artiodactyle (whose anatomy is known) is the common form, from which the two types may have diverged, of spiral visible. But the rudimentary spiral of the Galaginæ and Lorisinæ (among Lemurs) is a spiral from which both types of Artiodactyle spiral *might* be derived. (See p. 185.)
- (11) The remarkable spiral of the Musk-Ox, described by Lönnberg, in which the emergent limb is bent once upon itself before leaving the region of the spiral, is closely paralleled in one specimen (out of two) of the Rodent *Dasyprocta punctata*. (See p. 187.)
- (12) The azygos vein of *Madoqua* is like that of *Rhaphicerus* and *Ourebia* in that the left azygos has an anteriorly running branch as well as the chief posteriorly running trunk. These genera are usually placed in the same subfamily—Neotraginæ. (See p. 188.)
- (13) In the brain of *Madoqua*, as in that of other *small* Ruminants, the splenial sulcus is exposed and superficial in position. (See p. 190.)
- (14) The brain of *Babyrussa* is like that of other Old World Suidæ. Its slight divergences are not in the direction of the New World *Dicotyles*. (See p. 192.)
- (15) The brain of *Antilocapra* is remarkable for its squared-off ending anteriorly and for the fact that, as in the Suidæ, the crucial and coronal sulci are confluent. (See p. 173.)

3. Le Rhinocéros blanc du Soudan (*Rhinoceros simus cottoni*).

Par le Dr. E. L. TROUESSART, C.M.Z.S., Professeur au Muséum d'Histoire Naturelle de Paris.

[Received January 21, 1909.]

[Plates XXIX.—XXXI.]

Bien que les cornes du *Rhinoceros simus* soient, depuis le Moyen-Age, l'objet d'un commerce important dans le Soudan, et bien que plusieurs Musées d'Europe possèdent depuis longtemps de ces cornes, c'est seulement en 1900 qu'un crâne, rapporté par le Major A. Gibbons de l'enclave de Lado, permit d'affirmer avec certitude que cette espèce, en voie d'extinction au sud du Zambèze, était représentée, dans la région qui s'étend entre le Haut-Nil et le lac Tchad, par une sous-espèce distincte. Depuis cette époque, d'autres spécimens, rapportés par le Major P. H. G. Powell-Cotton de la même localité (Lado), ont permis à M. R. Lydekker de caractériser cette sous-espèce sous le nom de *Rhinoceros simus cottoni**.

Il ne semble pas que cette remarquable sous-espèce ait encore été figurée d'une manière satisfaisante. Je saisis donc l'occasion de donner ici, de profil et de face, la photographie d'un beau mâle, tué en 1908, dans le Bahr-el-Gazal, par un sportsman qui désire garder l'anonyme. La Planche XXIX. a été exécutée d'après ces photographies, et la figure de la femelle d'après une corne appartenant aux collections du Muséum d'Histoire Naturelle de Paris.

Si la figure du *Rhinoceros simus* de l'Afrique australe, publiée en 1894 par M. Coryndon† dans les 'Proceedings,' d'après le spécimen monté du Musée de Tring, était exacte, le *Rhinoceros simus cottoni* différerait très notablement du type du Mashonaland. Ce dernier, à part le caractère du museau, est figuré comme ayant les mêmes proportions que le *Rhinoceros bicornis*. Le Rhinocéros blanc du Soudan a des proportions bien différentes et que l'on pourrait qualifier de "plus élégantes," si cette expression pouvait s'appliquer à un Rhinocéros. Le corps est plus élevé et plus court, le garrot forme une saillie très notable, et par contre la croupe est déclive, *avalée* suivant le terme consacré en hippologie. Chez le *Rh. bicornis*, le garrot n'est pas plus élevé que la croupe.

Mais un caractère qui est nettement accusé sur nos deux photographies, c'est que la peau porte des *tubercules arrondis et saillants*, qui rappellent ceux des Rhinocéros asiatiques, bien que moins développés. Ce caractère paraît faire défaut au *Rhinoceros simus* de l'Afrique australe aussi bien qu'au *Rh. bicornis*, dont la peau ne présente que des plis assez irréguliers. L'œil paraît aussi plus développé ici, si j'en juge par un dessin de

* R. Lydekker, 'Field,' 22 February, 1908, p. 319; id. 'The Game Animals of Africa,' 1908, p. 38.

† Proc. Zool. Soc. 1894, p. 329, pl. 18.—La figure donnée par A. Smith, Illustr. of Zool. South Africa, 1849, pl. 19, semble plus exacte.



J. Terrier, del. pinx

RHINOCEROS SIMUS COTTONI ♂, ♀.



RHINOCEROS SIMUS COTTONI, ♂.



RHINOCEROS SIMUS COTTONI. ♂.

la tête du *Rh. simus* que j'ai sous les yeux et qui porte la légende : " Dessiné dans l'Afrique Méridionale d'après la nature par W^m J. Burchell " *.

D'après les renseignements que l'on possède actuellement sur la distribution géographique de la forme septentrionale de l'espèce, elle existe non seulement dans l'enclave de Lado, mais aussi dans le Bahr-el-Gazal et le Wadaï, probablement jusqu'au lac Tchad. La question de savoir si l'espèce existe plus au sud, entre le Zambèze et les sources du Nil, notamment dans la région des Grands Lacs, doit être réservée. En effet, Speke, au cours de son voyage de Zanzibar à l'Uganda (en 1860), parle de Rhinocéros " blancs et noirs " rencontrés dans le Karagwe, par conséquent entre les lacs Tanganyika et Kivu et le Victoria Nyanza †. Ce serait même là, si je ne me trompe, la plus ancienne mention, faite par un voyageur digne de foi, de la présence du *Rhinoceros simus* au nord du Zambèze. Les très longues cornes décrites sous les noms de *Rh. oswelli* Gray ‡ et *Rh. holmwoodi* Sclater § doivent être rapportées au mâle ou à la femelle de la présente espèce, et la provenance de celles-ci (par Zanzibar) indiquerait que l'animal qui les porte se trouve sur la rive gauche du Zambèze.

Mais, on peut affirmer que la présence de cet animal dans le nord de l'Afrique était déjà connue dans l'antiquité grecque et romaine. Diodore de Sicile, contemporain de Jules César, parle d'un Rhinocéros d'Ethiopie qui portait " à l'extrémité des narines une seule corne un peu aplatie et presque aussi dure que du fer," et qui livrait combat à l'Éléphant. Cette corne " un peu aplatie," placée à l'extrémité des narines et, de plus, suffisamment aiguë pour qu'on puisse supposer, à tort ou à raison, qu'elle est capable de percer le ventre de l'Éléphant, ne peut s'appliquer qu'au *Rh. simus*.

Cette espèce ayant en réalité deux cornes, on a longtemps mis en doute l'exactitude de ce passage de Diodore. Mais Fresnel ||, en 1848, nous apprend que les Arabes, qui font commerce des cornes du *Rh. simus*, sont absolument persuadés que l'animal n'a qu'une seule corne. La corne postérieure, toujours beaucoup plus petite, souvent tout-à-fait rudimentaire chez la femelle, est probablement négligée par le commerce, ou confondue avec les cornes du *Rh. bicornis*, considérées comme de qualité inférieure. Les Arabes du Soudan distinguent à première vue les cornes des deux espèces. Le commerçant Arabe de Djeddah qui renseignait Fresnel sur ce prétendu Rhinocéros unicolore, lui en donna la preuve. Il fit sortir dans la rue un serviteur qui portait une de ces grandes cornes sur chaque bras, et Fresnel entendit les passants prononcer, sans hésiter, le nom d'*Abou-Karn* (possesseur d'une corne), tandis que le Rhinocéros bicolore ordinaire s'appelle *Khertit*.

* Ce dessin est reproduit dans le ' Bulletin de la Société Philomatique,' 1817, pl. en face de la p. 100.

† Speke, ' Journal of the Discovery of the Source of the Nile,' 1863, p. 197.

‡ Proc. Zool. Soc. 1854, p. 46, fig. 1.

§ Proc. Zool. Soc. 1893, p. 517, figs. 1 et 2.

|| Fresnel, " Sur l'existence d'une espèce unicolore de Rhinocéros dans la partie tropicale de l'Afrique," Comptes-Rendus de l'Acad. des Sciences de Paris, 1848, t. xxvi. p. 281.

Les nègres du Soudan s'emparent du *Rhinoceros simus* en creusant de grandes fosses, masquées par de la terre et du feuillage, sur le chemin qu'il a coutume de suivre. Contrairement à l'opinion des voyageurs dans le sud de l'Afrique, on considère, dans le Soudan, la grande espèce comme plus dangereuse que le *Rh. bicornis* ordinaire. Le voyageur Tunisien Mohammed-al-Tounisi, qui visita le Wadaï vers 1825 *, rapporte que le Sultan de ce pays fut chargé par un Rhinocéros blanc. Nous savons aussi que, dans le sud de l'Afrique, Oswell eut son cheval éventré sous lui par un *Rh. simus*.

Le commerce considérable de cornes de Rhinocéros des deux espèces d'Afrique que les Arabes font, depuis une époque reculée, semble peu connu en Europe. Ces cornes sont exportées, par les ports de la Mer Rouge et de l'Océan Indien, pour l'Arabie, la Perse et la Chine, où on les sculpte comme de l'ivoire. On en fait des coupes, des manches de couteaux, de poignards et de sabres, des plaques de ceintures et d'autres objets. Le Muséum d'Histoire Naturelle de Paris possède trois coupes sculptées dans de la corne de Rhinocéros; l'une d'elle est d'un travail très artistique et d'un goût très pur, que ne renierait pas un sculpteur européen. La corne, travaillée de cette manière, prend un très beau poli, devient translucide dans les parties amincies, et sa couleur varie du rouge-grenat au jaune-brun.

Le Rhinocéros blanc est très probablement l'*Unicorne* ou *Licorne* des anciens. Ctésias (410 av. J.C.) nous apprend que, dès cette époque, on creusait dans la corne de Rhinocéros des coupes qui avaient la réputation de mettre ceux qui s'en servaient pour boire à l'abri de l'effet des poisons. C'est seulement au moyen-âge que la défense de *Licorne de mer* ou Narwal (*Monodon monoceros*) fut considérée comme ayant la même propriété, et placée sur le front de la Licorne héraldique qui figure comme *support* dans les armes de la Grande-Bretagne.

Mais l'ivoire de cette défense n'a jamais pu être creusé en forme de coupe à boire. Au contraire, les grandes cornes du *Rhinoceros simus*, qui atteignent quelquefois, chez la femelle, la longueur de 1^m 57, ont dû frapper l'imagination des anciens, et leur large base était très propre à être façonnée en forme de coupe.

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PLANCHE XXIX.

Rhinoceros simus cottoni, ♂ et ♀, du Bahr-el-Gazal, d'après une aquarelle de M. Terrier.

PLANCHE XXX.

Rhinoceros simus cottoni, ♂, de profil, photographie prise au Bahr-el-Gazal.

PLANCHE XXXI.

Rhinoceros simus cottoni, ♂, le même, vu de face, id.

* Mohammed-al-Tounisi, ' Voyage au Wadaï,' trad. française, 1851.

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The 'Proceedings' for the year are issued in *four* parts, paged consecutively, so that the complete reference is now P. Z. S. 1909, p. . . . The Distribution is as follows:—

Papers read in January and February, issued in June.

" " March and April, " " August.

" " May and June, " " October.

" " November and December, " " April.

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The Abstracts of the papers read at the Scientific Meetings in January and February are contained in this Part.

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1909.

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March 2, 1909.

G. A. BOULENGER, Esq., F.R.S., Vice-President,
in the Chair.

Mr. R. H. Burne, F.Z.S., exhibited and remarked on the following specimens of certain elastic mechanisms in Fishes and Reptiles:—

“1. The *ligamentum longitudinale ventrale* of a Shad (*Clupea alosa*).

The ligament lies in the cavity of the aorta suspended by a longitudinal fold of its dorsal wall. In front it is firmly attached to the basioccipital; in the trunk region it is free except for the mesentery-like fold of the aortic wall by which it is suspended (text-fig. 20, M., p. 202); and in the tail region it becomes more and more closely attached to the ventral surface of the vertebral column, projecting merely as a ridge into the cavity of the aorta.

The ligament itself is a round or oval band of elastic tissue forming in the trunk region a thickened edge to a longitudinal curtain that divides the cavity of the aorta into two lateral channels.

The ligament is extremely tight, so much so that when the trunk muscles are removed, it draws the vertebral column into a series of lateral serpentine curves. Its strength is also shown by the large size of the elastic ligament between the neural spines.

In the trunk region the aorta is peculiarly spacious, filling a wide channel upon the ventral surface of the vertebral column, bounded by the flat lower surface of the vertebral column above and by a series of quadrangular hæmal arches at the sides and below.

There is little doubt that this ligament is concerned in the propulsion of blood within the aorta. The following explanation of its action was suggested to me several years ago by the late Professor Charles Stewart.

When a Fish swims, lateral flexions, alternate from side to side, pass regularly down the body from head to tail. This is most manifest in such Fishes as the Eels and Dogfish, but in comparatively stiff fishes such as the Herrings the action is the same although the chief and most powerful flexion takes place when the wave of contraction nears the tail.

It is clear that the aorta will take part in these flexions—a swing to either side sweeping in regular sequence from head to tail (text-fig. 21, p. 203).

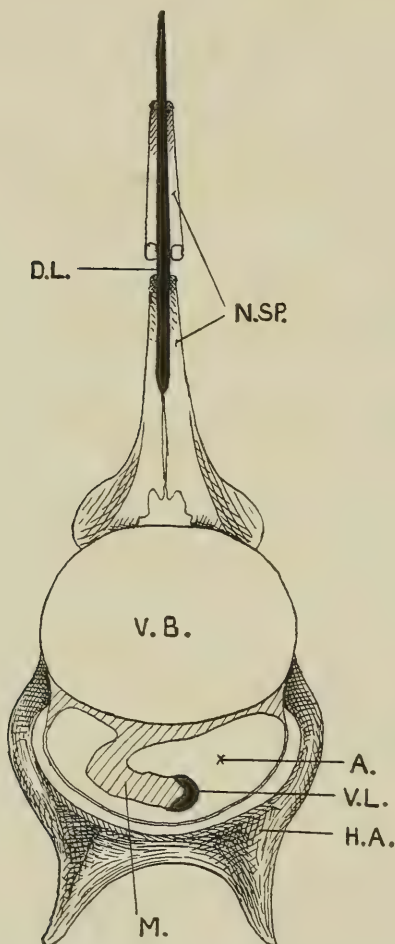
But the ventral ligament owing to its tension will remain practically stationary and will in effect form a series of diagonal curtains passing regularly in succession down the length of the aorta. Each curtain will of necessity push the blood before it.

The faster the fish swims the faster will become the blood stream in the aorta.

This ventral longitudinal ligament is found in, I believe, all
Proc. Zool. Soc.—1909, No. XIV.

Herrings and also in the Sturgeons, and it is particularly interesting to note that in both these groups of Fishes the aorta has a similar character, being a wide capacious vessel enclosed

Text-fig. 20.



A transverse section through the vertebral column and aorta of a Shad, in the region of the trunk.

A. Aorta. D.L. Dorsal elastic ligament. H.A. Hæmal arch. M.[†] Suspensory membrane of the ventral ligament. N.SP. Neural spines. V.B. Body of vertebra. V.L. Ventral ligament.

within a more or less complete skeletogenous and unyielding sheath. This is particularly so in the Sturgeon, where the vessel

forms a closely adherent lining to a continuous cartilaginous canal.

In any case the aorta is to a great extent cut off from the direct effects of those internal movements and pressures to which in Fishes the arterial circulation is probably to a large extent due, as in the veins of Mammals.

We thus see in the case of these particular fishes the advantage of some special mechanism to aid the circulation of the blood.

Text-fig. 21.



Diagrams of one and the same portion of the aorta, showing the relative positions of the ventral ligament and aortic cavity during the lateral flexions of the body in swimming.

The ligamentum longitudinale is apparently formed around, though not actually from, the subchordal rod*—a structure that occurs as a transitory foetal organ in Fishes and Amphibia, and from its mode of development appears to be the vestige of the epipharyngeal groove of *Amphioxus*.

* Franz, Morph. Jahrb. Bd. 25, 1897.

2. The framework, muscles, and ligaments of a gill-pouch of *Raja maculata*.

The expansion of the gill-pouch during the inspiratory movement is due to a series of elastic ligaments acting upon the branchial rays, drawing them away from the central member of the series.

3. An elastic modification of the anterior wall of the capsule of the costo-vertebral joints in a Python (*P. sebae*).

This part of the capsule-wall is greatly thickened and consists almost entirely of elastic fibres arranged parallel to one another and to the long axis of the rib.

The action of this plate of elastic tissue would no doubt be to protract the rib upon the relaxation of its retractor muscles.

In Snakes forward locomotion is largely due to the forcible retraction of the ribs, their protraction being rather in the nature of a recovery to a state of repose—a movement requiring comparatively little force.”

Dr. R. F. Scharff, B.Sc., F.Z.S., exhibited some long-bones and antlers of Reindeer from a cave in County Cork in Ireland.

He stated that Reindeer bones had been discovered sparingly in caves in the Counties of Sligo and Clare along with those of the Greenland Lemming (*Dicrostonyx torquatus*). During the Co. Cork cave explorations, the results of which will shortly be published in detail, Reindeer remains were found in extreme abundance. They were associated with the bones of Hyæna and two species of Lemming.

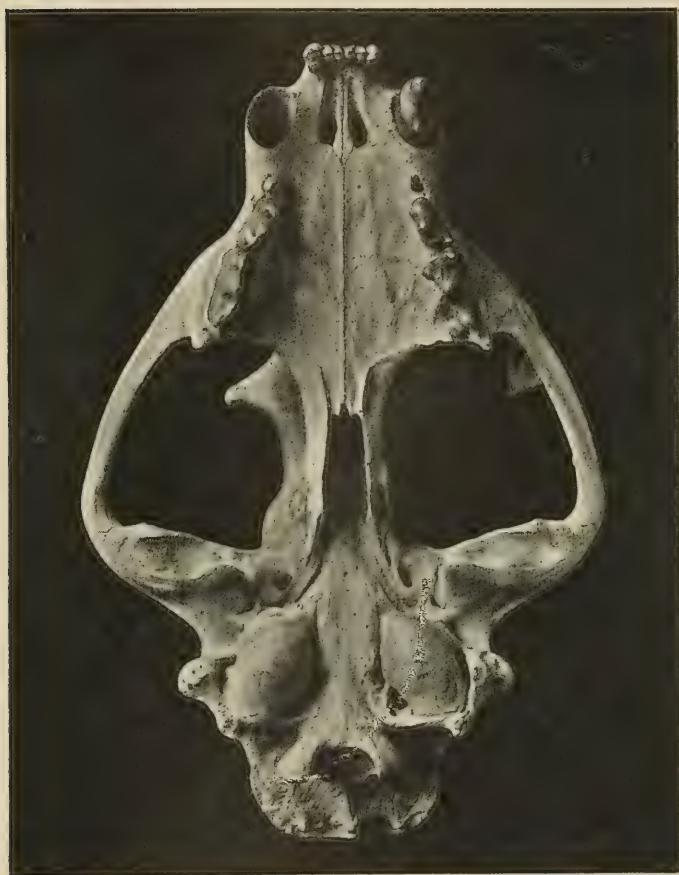
The main object of exhibiting the Reindeer bones was to draw attention to the fact that many of them showed distinct traces of having been gnawed by some other animal. Dr. Scharff had suggested that the tooth-marks might have been produced by young hyænas, but was disposed to accept the view that they were produced by Rodents. The marks on the antlers seemed to differ from those on the long-bones, the latter having often been gnawed through entirely in the middle.

Mr. Pocock on the Skulls of Leopards.

Mr. R. I. Pocock, F.L.S., F.Z.S., the Superintendent of the Gardens, exhibited the skulls of some West African Leopards which had come from Cette Cama in the Gaboon, and made the following remarks:—“I owe to Mr. Edward Gerrard, taxidermist, of Camden Town, the opportunity of examining these skulls, which he sent to me on account of their unusual size. He was struck by the fact that three of them surpass in dimensions all the Leopards' skulls out of the very large number that have passed through his hands, and are particularly remarkable for the length and thickness of the canine teeth. A comparison between their measurements and those cited in Rowland Ward's ‘Records of

Big Game,' p. 500, 1907, shows that all three exceed both in length and width the largest therein recorded, the measurements of which were taken from an example from the North-Western Provinces of India. They also surpass in dimensions all the

Text-fig. 22.



Skull of Leopard (*Felis pardus leopardus*) from Cette Cama. Ventral view.
(No. 1 in table on page 208.)

Leopards' skulls I have seen in the collection of the British Museum and all those in the collection of the Society. Moreover, although their shape indicates very considerable development of the temporal muscles, the persistence of the divisional lines between the bones of the brain-case and the unworn character

of the teeth show that they are not skulls of old Leopards, and suggest that they might have grown even larger if the animals had not been killed. In one indeed (No. 3) the occipital suture is still open. The locality proves practically beyond doubt that they belong to the tropical West African race of the Leopard (*Felis pardus*) which should be called *F. pardus leopardus**.

Text-fig. 23.



Skull of Leopard (*Felis pardus pardus*) from Mhow, C.P., India. Ventral view.
(No. 9 in table on page 208.)

From the largest Leopard's skull in the collection of the Society, they exhibit some very striking differences as the subjoined table

* Pocock, P. Z. S. 1907, p. 675.

of measurements shows (p. 208). This skull itself nearly reaches record dimensions since it exceeds in zygomatic width by half an inch the largest recorded by Rowland Ward ($7\frac{1}{8} : 6\frac{5}{8}$) and falls only a quarter of an inch short of it in total length ($10 : 10\frac{1}{4}$). It belonged to an exceptionally fine male from Mhow in the Central Provinces of India, presented to the Society by Mr. Pelham. This Leopard was of the typical race *F. pardus pardus*. Not only is this skull from Mhow broader across the premaxillæ than the Cette Cama specimens, but it also differs from them in having much smaller auditory bullæ, the width of these being less than the width of the basioccipital area between them, instead of being greater; but most of all does it differ in the width and shape of the mesopterygoid fossa, which is wider in front than behind and has a sinuous concavo-convex edge owing to the incurvature of the pterygoid bones; whereas this fossa in the Cette Cama skulls has almost parallel sides and is comparatively long and narrow though varying individually in these respects. It is also of interest to record that a Leopard's skull of average dimensions belonging to a male, presented to the Society by Mr. F. H. Melland and captured on the Luangwe River in North-east Rhodesia, has the mesopterygoid fossa shaped more like that of the specimen from Mhow than like the fossa of those from Cette Cama; and that in the equality in width between the auditory bullæ and the intervening area of the basioccipital, it occupies an intermediate stage. As I have already stated*, this Luangwe Leopard also differs from the typical West African form in colour, its yellow hue recalling that of most Indian specimens, although the spots are much smaller. This fact and the differences in the skull above recorded indicate that it represents a distinct subspecies from *F. pardus leopardus*; but in the present very unsatisfactory state of our knowledge of East and South African Leopards, I do not feel justified in applying to it a name, either new or old.

Mr. Gerrard also sent to me with the three above mentioned skulls from Cette Cama, doubtless belonging to male specimens, a single skull of what I take to be a female animal, which was shipped from the same port at the same time together with some spoils of Gorillas and Chimpanzees. The closure of the cranial sutures shows that the specimen was adult and yet it is remarkably small, being 3 inches shorter and more than 2 inches narrower than the smallest of the three large ones (*cf.* measurements). This skull lends support to the oft-repeated statements of sportsmen that two kinds of Leopards, larger ones called Panthers and smaller ones called Leopards, occur in the same localities.

So far as size goes this small specimen approaches much nearer the typical skull of the dwarf Leopard of Somaliland described by Thomas as *F. pardus nanopardus*, a Leopard which, together with

* P. Z. S. 1907, p. 676.

	Cette Cana.				Luangwe River.	French Congo.	Fort Manning.	Somaliland. (<i>nanopardus</i>)	Mhow (India).
	1.	2.	3.	4 (♀?)					
Total length	11 $\frac{1}{8}$	10 $\frac{3}{4}$	10 $\frac{1}{2}$	7 $\frac{1}{2}$	8 $\frac{3}{4}$	9 $\frac{1}{4}$	9 $\frac{1}{8}$	6 $\frac{3}{4}$	10
Basal length	9	8 $\frac{7}{8}$	8 $\frac{3}{4}$	6 $\frac{1}{4}$	7 $\frac{1}{8}$	—	—	—	8 $\frac{3}{4}$
Length of palate (external to middle line)	4 $\frac{1}{2}$	4 $\frac{5}{8}$ +	4 $\frac{1}{2}$	3	3 $\frac{5}{8}$	4 $\frac{1}{8}$	4	—	4 $\frac{1}{4}$
Width across zygomata	7 $\frac{1}{8}$	7	7 $\frac{1}{8}$	4 $\frac{1}{2}$	5 $\frac{3}{4}$	5 $\frac{7}{8}$	5 $\frac{3}{4}$	3 $\frac{7}{8}$	7 $\frac{1}{8}$
“ between orbits	1 $\frac{3}{4}$	1 $\frac{7}{8}$	1 $\frac{3}{4}$	1 $\frac{1}{8}$	1 $\frac{3}{8}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	—	2 $\frac{1}{8}$
“ across postorbital processes	3 $\frac{3}{8}$	3 $\frac{1}{4}$	—	2 $\frac{1}{4}$ +	2 $\frac{3}{4}$	2 $\frac{3}{4}$	2 $\frac{5}{8}$	—	3 $\frac{1}{2}$
“ behind ditto (waist)	1 $\frac{3}{8}$	1 $\frac{7}{8}$	1 $\frac{5}{8}$	1 $\frac{5}{8}$	1 $\frac{3}{4}$	2	1 $\frac{3}{8}$	—	1 $\frac{1}{4}$
“ across parietals	2 $\frac{7}{8}$	3	2 $\frac{3}{4}$	2 $\frac{1}{2}$	2 $\frac{5}{8}$	—	—	—	2 $\frac{5}{8}$
“ across maxillæ (outside canines)	2 $\frac{1}{2}$	2 $\frac{3}{4}$	2 $\frac{5}{8}$	1 $\frac{7}{8}$	2 $\frac{1}{4}$	2 $\frac{1}{2}$	2 $\frac{1}{4}$	—	2 $\frac{3}{4}$
“ across premaxillæ (alveolar border)	1 —	1	1 +	3 $\frac{1}{4}$	1 $\frac{7}{8}$	1	1 $\frac{7}{8}$	—	1 $\frac{1}{4}$
“ mesopterygoid fossa (at pal. pt. suture)	9 $\frac{1}{10}$	1 $\frac{1}{10}$	3 $\frac{3}{4}$	5 $\frac{5}{8}$	3 $\frac{3}{4}$	5 $\frac{5}{8}$	3 $\frac{3}{4}$	—	1
“ outside ditto	1 $\frac{1}{10}$	1 $\frac{1}{4}$	1 $\frac{5}{8}$	1 $\frac{7}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{10}$	—	1 $\frac{1}{2}$
“ of auditory bulla	1 $\frac{1}{8}$	1 $\frac{1}{10}$	1 +	1 $\frac{7}{8}$	1 $\frac{7}{8}$	1	1	2 $\frac{3}{4}$	1
“ between bullæ	7 $\frac{7}{8}$	1 $\frac{5}{10}$	1 $\frac{5}{8}$	1 $\frac{1}{2}$	1 $\frac{7}{8}$	1 $\frac{7}{8}$	1 $\frac{7}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{8}$
Length of pm ⁴	1 $\frac{1}{10}$	1 $\frac{1}{8}$	1	1 $\frac{7}{8}$	1 $\frac{7}{8}$	1 $\frac{1}{8}$	1	2 $\frac{3}{4}$	1
“ canine	2 $\frac{1}{8}$	2 $\frac{1}{4}$	1 $\frac{7}{8}$	1 $\frac{3}{8}$	1 $\frac{1}{4}$	—	1 $\frac{5}{8}$	—	1 $\frac{1}{2}$
“ ditto (enamel)	1 $\frac{5}{8}$	—	—	—	1 $\frac{1}{8}$	—	1 $\frac{5}{8}$	—	1 $\frac{1}{4}$
Width of canine (base)	3 $\frac{3}{4}$	2 $\frac{7}{8}$	3 $\frac{3}{4}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	—	1 $\frac{1}{2}$	—	1 $\frac{1}{2}$

its normal-sized congener coming from Somaliland, furnishes the most striking instance known of a larger and smaller form occurring in the same country.

In the subjoined table I have placed side by side for comparison measurements in English inches * of eight skulls of African Leopards and of one Indian example, namely, the above mentioned one from Mhow. Nos. 1-4 are the four examples from Cette Cama lent to me by Mr. Gerrard. No. 5 is Mr. Melland's Luangwe River small-spotted specimen. No. 6 is an example in the British Museum sent from the French Congo by Mr. G. L. Bates. Although smaller than the large Cette Cama skulls, this presents the same general features and has the mesopterygoid fossa narrow, with nearly parallel edges. No. 7 is a specimen from Fort Manning in Nyasaland, in the British Museum. Although considerably smaller than No. 3 of the Cette Cama series and larger than the Luangwe River example, this skull has the mesopterygoid fossa of the same actual width. The skull of another Leopard from Zomba in Nyasaland, however, has the mesopterygoid fossa broad, namely $\frac{1}{3}$ of an inch, that is to say very nearly as broad as in the considerably larger Indian example from Mhow. It will be seen therefore that the marked distinction in width and shape of the mesopterygoid fossa between Indian and West African Leopards breaks down in East and South African specimens, as is attested by the skull from Zomba, the one from Fort Manning, and also one from Cape Colony in the British Museum. The fossa in question is wide in all the Asiatic Leopards' skulls that I have seen, including specimens from India, North China (*F. pardus fontanieri*), Hong Kong, and of the Black variety from Malacca. It is also broad in the skulls of Jaguars (*F. onca*) and points to closer relationship, also borne out by the pattern, between Jaguars and Asiatic Leopards than between Jaguars and West African Leopards, a conclusion to be expected from geographical distribution. On the other hand, the anterior border of the fossa is at all events as a rule produced backwards into a sharply pointed angle in Asiatic Leopards, whereas in African Leopards it is generally at least markedly straighter, sometimes indeed slightly notched, and in Jaguars this edge is usually notched, as it is also in Lions.

In conclusion it may be said that Asiatic Leopards (*F. p. pardus*, *fontanieri*, etc.) have the mesopterygoid fossa wide, with arcuate lateral edges and the anterior edge strongly angled. West African Leopards (*F. p. leopardus*) have the mesopterygoid fossa narrower, with subparallel lateral edges and a straighter anterior border, whereas in East and South African animals some present one form of fossa and some the other; but I have not seen sufficient material to contribute anything further to the elucidation of the local races of Leopards, occurring between Abyssinia and Cape Colony.

* An English inch = 25 mm.

The following papers were read :—

1. The Development of the Subdivisions of the Pleuro-peritoneal Cavity in Birds. By MARGARET POOLE.*

[Received February 9, 1909.]

(Text-figures 24–37.)

The subject of this paper was suggested to me by Professor Bourne, and it was by his advice that I undertook a reinvestigation of the development of the subdivisions of the body-cavity in birds; my object being to confirm and enlarge the results put forward in a paper on the subject by Mr. G. W. Butler in these 'Proceedings.' At that time I knew of no other work on this part of the question; and it was only when I had almost completed my study of the development of these structures, that Mr. Beddard kindly referred me to the work of Dr. Bertelli. This I found was published in an Italian journal not—so far as I could discover—taken in by any of the scientific libraries either in Oxford or London; and it was only by the very great kindness of Dr. Bertelli, who sent me a copy, that I was at last able to see it. I then found that he had worked out and described in great detail and with admirable clearness, almost the whole of the development upon which I was engaged. But since this valuable paper is practically inaccessible to English students, Dr. Bourne advised me to publish the results of my own investigations, which I had arrived at independently. I may here state that my results entirely confirm those of Mr. Butler, and, except in two small points, those of Dr. Bertelli also.

† The work was done in the Zoological Laboratory at Oxford by the kindness of Professor Bourne, and I wish to take this opportunity of expressing my warmest thanks to all in the Department—and especially to Mr. Goodrich—who have helped me by continual suggestions and advice.

I wish likewise to express my gratitude to Dr. Bertelli for his kindness, not only in sending me a copy of his work, but also for his permission to make any use of his observations in my own paper.

NOMENCLATURE.

The pulmonary aponeurosis of Huxley [12] and Butler [9]—diaphragme pulmonaire of Sappey [16]—Bertelli [6, 8] calls the *diaframma ornitico*.

The oblique septum of Huxley, employed by Butler, Beddard and others—the diaphragme thoraco-abdominal of Sappey—Bertelli does not consider to be a septum at all, but only the ventral walls of the intermediate air-sacs together with the posterior wall of

* Communicated by Prof. G. C. BOURNE, D.Sc., F.Z.S.

the pericardium. Butler takes the pulmonary aponeurosis and the oblique septum as forming together a single septum, which he terms the avian diaphragm. The backward prolongation of this in connection with the development of the posterior air-sacs, he calls the oblique abdominal septum. Since, however, Bertelli's diaframma ornitico is but half of Butler's avian diaphragm, I shall use neither of these terms, but call the whole of Butler's avian diaphragm together with his oblique abdominal septum, the post-pulmonary septum; this, in the early stages of its development, corresponds to what Bertelli calls the "diaframma primario."

For the air-sacs I shall use the terms employed by Bertelli in his earlier paper [7]:—Anterior intermediate, posterior intermediate, and posterior; except for the latter, which he calls abdominal, Butler uses the same names.

The blind anterior diverticula of the peritoneal cavity I shall call, after Butler, the pulmo-hepatic recesses; these are the "recessi polmonali-enterici" of Bertelli. Butler's pulmo-hepatic ligaments correspond to Bertelli's ventral pulmonary ligaments, and I shall use these latter terms in describing the development.

Finally, I shall call, with Butler, the horizontal septum of Beddard [1] the post-hepatic septum; since this term, while indicating its essential position, does not depend upon its direction which is very variable.

I. EMBRYOLOGY.

The Post-pulmonary Septum.

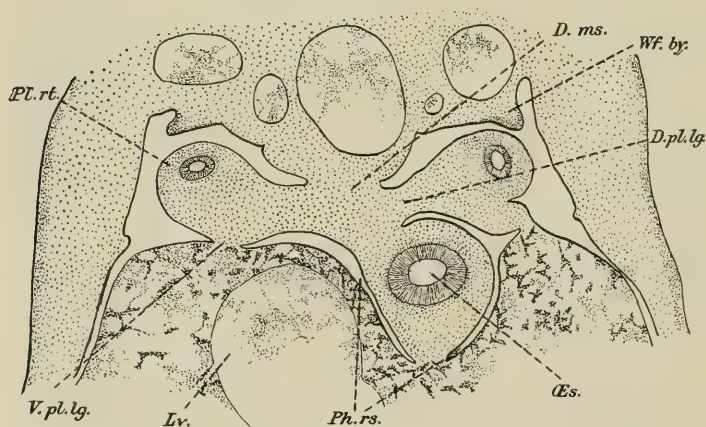
As it is important to follow the growth of the lungs from their first appearance, Bertelli begins his observations on chicks of 60 hours' incubation, though the septum does not begin to develop until much later. At this stage the bronchi are not yet formed, but the mesoderm into which they will grow appears as slight folds (meso-laterali) on the lateral faces of the median dorsal mesentery (setto mesenterico), projecting into the cœlomic cavity. That on the right side is united ventrally with the septum transversum, this being the vertical partition posterior to the pericardium which divides the latter from the peritoneal cavity, and in its more dorsal portion carries the two ductus Cuvieri inwards to the heart. After three days' incubation, the folds have increased in size, and both are now united ventrally with the septum transversum. The bronchi are formed, and have penetrated into the mesodermal folds, and so divided the latter each into three regions: a posterior, dorsal pulmonary ligament, a median, pulmonary rudiment (abbozzo polmonale), and an anterior, ventral pulmonary ligament. Between the ventral pulmonary ligaments on each side, and the median dorsal mesentery, lie the narrowed anterior prolongations of the peritoneal cavity—the pulmo-hepatic recesses. On the fourth day, the relations between these parts remain the same, but in a chick of five days' incubation the pulmonary rudiments have greatly

increased in size, and the ventral pulmonary ligaments have united ventrally with the lower edge of the median dorsal mesentery, the dorsal surface of the liver, and the pericardio-pleuro-peritoneal membrane. The latter is what is called in younger stages the septum transversum; it now forms a mass of tissue separating the pericardium from the pleural and the peritoneal regions of the cœlom. Posteriorly, the ventral pulmonary ligaments spread out laterally to unite with the antero-lateral corners of the now well-developed liver; and at the same time the dorsal pulmonary ligaments and the lung rudiments themselves assume an almost transversely horizontal position; so that in this region there is now a septum across the cœlomic cavity, complete except at its extreme lateral margins where the pleural and peritoneal divisions communicate by a narrow aperture on either side. At a later stage these passages will be closed by the union of the ventral pulmonary ligaments and the lateral body-walls, and thus the post-pulmonary septum—Bertelli's "diaframma primario"—will be formed.

The pronephric folds appear at this stage as thickenings of the connective tissue on the external walls of the anterior part of the pleuro-peritoneal cavity; posteriorly they are seen in close connection with the developing Wolffian bodies on the dorsal wall of the cœlomic cavity.

Text-fig. 24 is of a transverse section of a chick of 5 days'

Text-fig. 24.



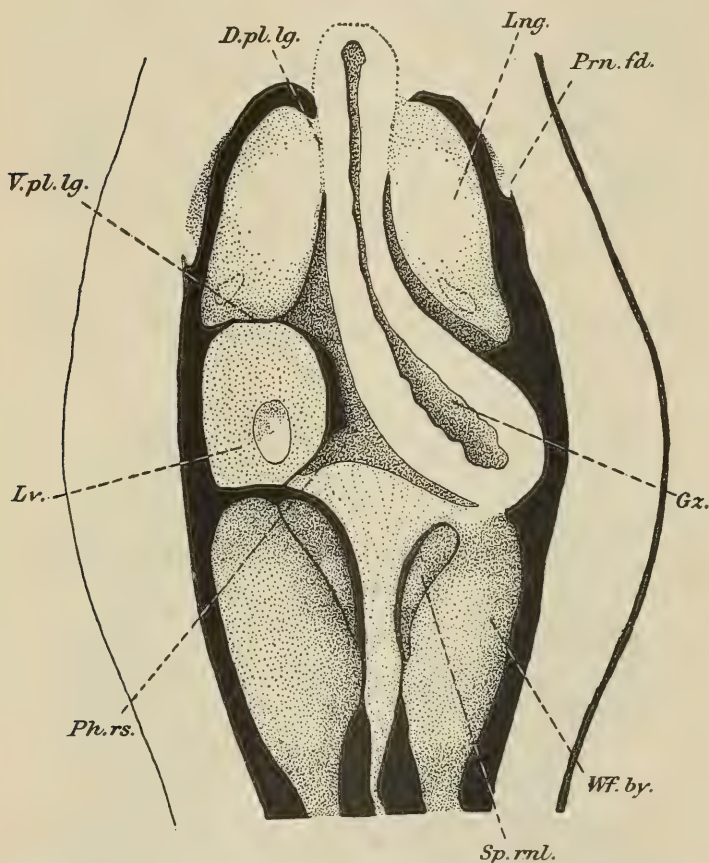
Transverse section of a chick of 5 days' incubation, through the anterior region of the liver; anterior face.

For explanation of abbreviations in text-figures see p. 235.

incubation, taken through the region where the septum will be formed, the anterior face being shown. The developing pronephros is seen on the dorsal wall of the pleuro-peritoneal cavity.

Text-fig. 25 is a slightly diagrammatic reconstruction from longitudinal horizontal sections of a chick of six days' incubation, seen from the ventral side. The pericardium and heart, the ventral part of the alimentary canal, and all the liver except the most dorsal corner of the right lobe have been removed.

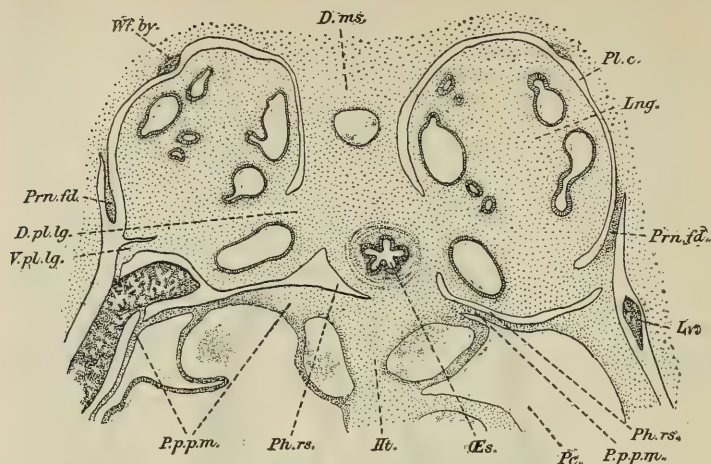
Text-fig. 25.



Slightly diagrammatic reconstruction from horizontal longitudinal sections of a chick of 6 days' incubation; seen from the ventral side. The pericardium and heart, the ventral part of the alimentary canal, and all the liver except the most dorsal corner of the right lobe have been removed.

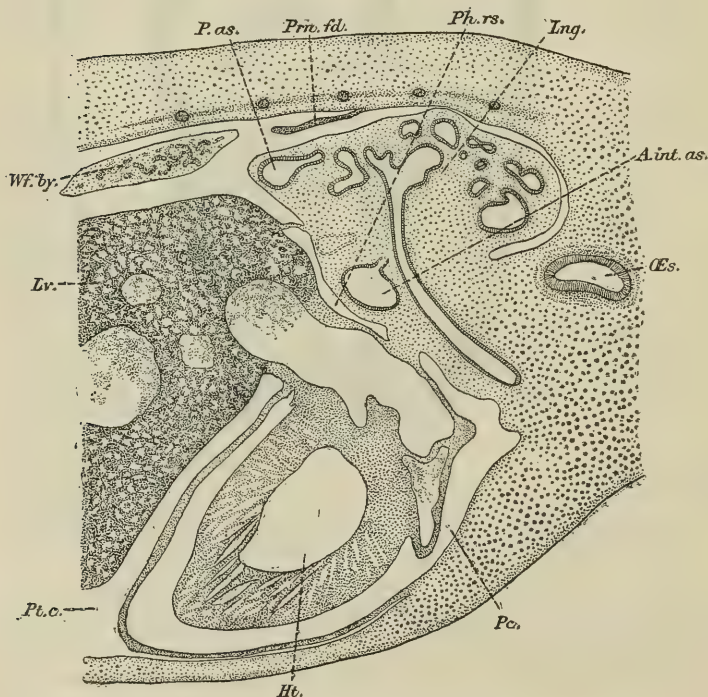
At this stage the two pairs of intermediate air-sacs first make their appearance, lying—together with the posterior air-sacs which are developed even earlier—in the ventral pulmonary ligaments. The pronephric folds are now seen, supporting the Müllerian ducts

Text-fig. 26.



Transverse section of a chick of 7 days' incubation, through the posterior part of the pericardium and anterior part of the liver; anterior face.

Text-fig. 27.



Longitudinal vertical section of a chick of 7 days' incubation, taken a little to the left of the middle line; seen from the right side.

at their extremities, projecting from the dorsal walls of the pleural parts of the cœlomic cavity. Posteriorly they unite with the pericardio-pleuro-peritoneal membrane, and thus for a short space, the pleural and peritoneal cavities are separated from one another. This is shown in text-fig. 26, which is of a transverse section of a chick of 7 days' incubation. On the left side of the section this connection has disappeared; on the right side it is lost a few sections further back, and then the two cavities communicate freely. Here the pronephric folds hang free from the lateral body-walls into the cœlom—as shown on the right side of the section—until they unite with the Wolffian bodies.

Text-fig. 27 is of a vertical longitudinal section through a chick of the same age.

On the eighth day of incubation, immediately above their connection with the pericardio-pleuro-peritoneal membrane, the ventral pulmonary ligaments have united with the lateral body-walls, and thus formed a part of the post-pulmonary septum. The air-sacs are now quite large, and by their backward growth have pushed the connective tissue of the more median portions of the ventral pulmonary ligaments, together with the tissue of the pericardio-pleuro-peritoneal membrane at the posterior edge of the lungs—which at this time cannot be distinguished from the pulmonary tissue itself—before them into the peritoneal cavity. This post-pulmonary tissue on either side, containing the air-sacs, forms the antero-lateral wall of the pulmo-hepatic recess.

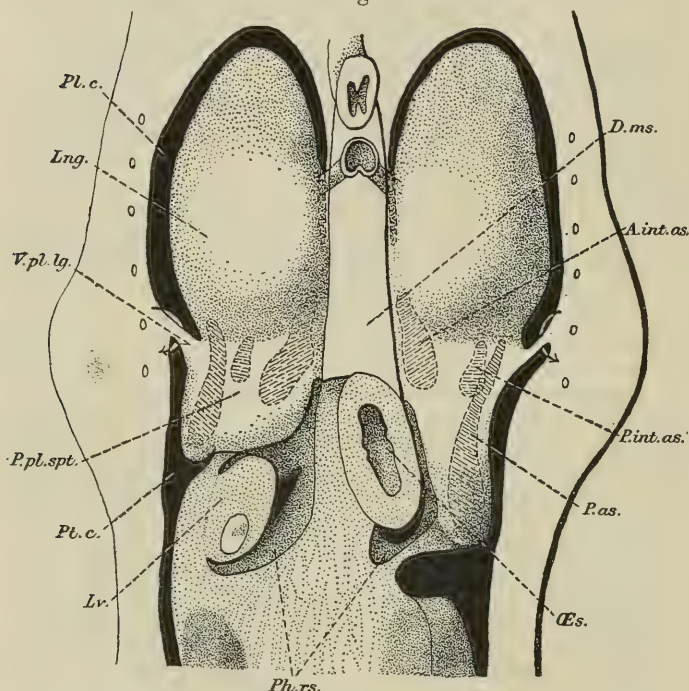
Text-fig. 28, p. 216, is a reconstruction similar to text-fig. 25 of a chick 8 days after the commencement of incubation. The pleural cavities are seen closed ventro-posteriorly by the union of the ventral pulmonary ligaments with the lateral body-walls. More dorsally, however, the communications with the peritoneal cavity are widely open, as is indicated by arrows.

Ventrally, the pronephric folds are attached to the dorsal surface of the ventral pulmonary ligaments where these unite with the lateral body-walls; behind this connection the folds hang free into the cœlom, bearing the Müllerian ducts at their extremities, until on the dorsal surface they unite with the Wolffian bodies.

On the tenth day of incubation, the pleural and peritoneal cavities are completely separated by the dorsal extension of the union between the ventral pulmonary ligaments and the lateral body-walls on either side. Besides this, however, the backwardly growing post-pulmonary tissue containing the air-sacs, which appeared on the eighth day as projecting freely into the peritoneal cavity, has become united with the lateral body-walls behind the ventral pulmonary ligament connection. As this union takes place gradually during the ninth day, from before backwards, the anterior prolongations of the peritoneal cavity—previously forming the lateral boundaries of the post-pulmonary masses of tissue—become completely obliterated. Thus the post-pulmonary septum, Bertelli's "*diaframma primario*," is established.

The anterior intermediate air-sacs are at this stage large oval vesicles lying in the post-pulmonary septum near the middle line and close against the base of the lungs. The posterior intermediate air-sacs are much smaller, and enclosed in the extreme lateral portions of the same septum. The posterior air-sacs, arising from the postero-lateral corners of the lungs, are very large and project backwards for a considerable distance into the peritoneal cavity. Bertelli says that their posterior ends project

Text-fig. 28.



Reconstruction, similar to text-fig. 25, of a chick of 8 days' incubation.

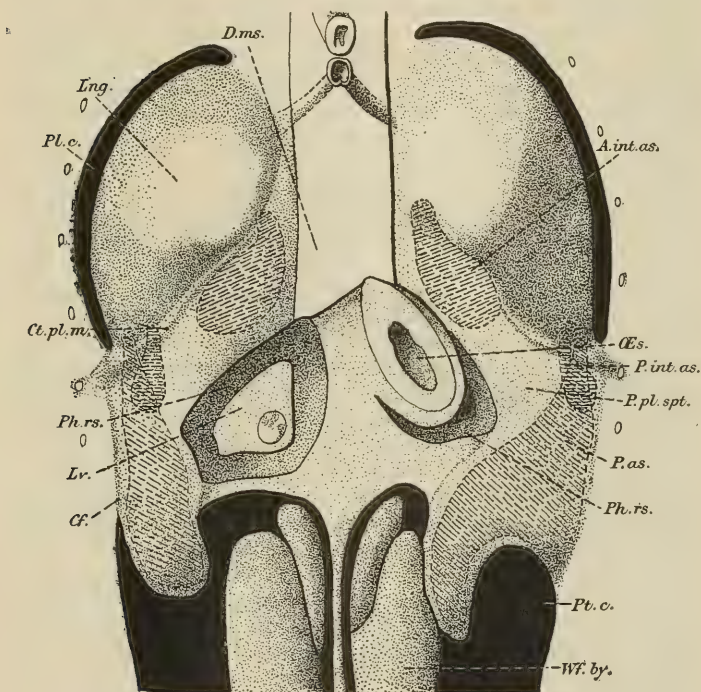
beyond the diaphragmatic tissue and thus "resta libero nella cavità addominale tra la parete laterale di questa, il corpo di Wolff e l'intestino a sinistra, tra la parete laterale dell' addome, il corpo di Wolff e il fegato a destra." On this point my own observations differ slightly from his. I believe that the posterior ends of these air-sacs never extend beyond the hindmost edge of the post-pulmonary septum. However far these air-sacs extend among the abdominal viscera, they always push before them a layer of connective tissue covered with cœlomic epithelium.

Text-fig. 29 is of a reconstruction, similar to text-figs. 25 and 28,

of these structures in a chick of 10 days' incubation. In addition, this figure shows the origin of the first costo-pulmonary muscles from the fifth ribs, which run into the post-pulmonary septum following the ventral and posterior border of the lungs. These will be supplemented by others arising later from the third, fourth, and sixth ribs, and give rise to the aponeurotic membrane, which in the adult covers the postero-ventral face of the lungs and separates these organs from the intermediate air-sacs.

The pronephric folds are attached ventrally to the antero-lateral walls of the post-pulmonary septum, and dorsally are connected with the external margins of the Wolffian bodies.

Text-fig. 29.



Reconstruction, similar to text-figs. 25 and 28, of a chick of 10 days' incubation.

The post-pulmonary septum, now fully formed from the median dorsal mesentery in the middle line, the pericardio-pleuro-peritoneal membrane with the ventral pulmonary ligaments, and slightly also from the pronephric folds laterally, constitutes a complete partition dividing the coelomic cavity into a pleural and a peritoneal portion. Bertelli calls this septum the

"*diaframma primario*" because he says it is a temporary structure which will later give rise to the "*diaframma definitivo*" and also to the ventral walls of the intermediate air-sacs. At this stage—ten days after incubation—he says the anterior intermediate air-sacs lie enclosed in the primary diaphragm, and by splitting it into two layers, form with their dorsal walls the definitive diaphragm and with their ventral walls the so-called "*diaframma toraco-addominale*." The posterior intermediate and the posterior air-sacs likewise split the primary diaphragm into two layers; and behind this he describes them as lying in the lateral abdominal walls, covered by their peritoneum, and bounded externally by the connective tissue which surrounds the muscles of the body-wall. Now I do not find any signs of these air-sacs actually penetrating into the walls of the peritoneal cavity so as to lie between its bounding cœlomic epithelium and the musculature of the body-wall. According to my observations, the air-sacs always remain enclosed in the backward prolongations of the post-pulmonary septa, and this tissue becomes closely attached—throughout its entire thickness—to the lateral body-walls. Between the post-pulmonary tissue surrounding the air-sacs and the connective tissue of the body-wall, in all my sections there is a darkly-staining streak, showing—I believe—where the two layers of cœlomic epithelium have fused together (text-figs. 29, 30, 31, *cf.*).

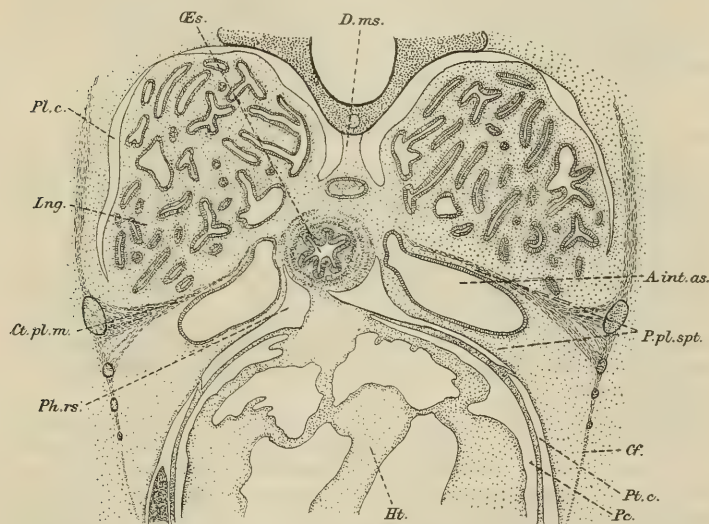
And I differ a little from Bertelli as to the formation of his "*diaframma definitivo*" from the antero-dorsal portion of the "*diaframma primario*"; though this divergence of opinion depends entirely upon my own conception of the essential nature of a cœlomic septum. I consider that such a septum should be covered on both surfaces by peritoneum, and really separate one division of the cœlom from another; and therefore I prefer—following Butler—to regard the whole post-pulmonary mass of tissue, with the intermediate and posterior air-sacs enclosed between its antero-dorsal and postero-ventral walls—the "*diaframma ornitico*" and the so-called "*diaframma toraco-addominale*" respectively of Bertelli—as a single septum. Except for the presence of the costopulmonary muscles in the antero-dorsal half of this septum, there is nothing to distinguish it, as the true diaphragm, from the postero-ventral portion, in the first stages when the splitting into two layers occurs with the development of the air-sacs. Besides which, the "*diaframma ornitico*" of Bertelli only separates the pleural cavities from the cavities of the intermediate air-sacs, and is consequently covered only on one face by peritoneal epithelium; the other surface being invested by the endoderm of the air-sacs. What I have described as the post-pulmonary septum, on the other hand, does really separate the pleural from the peritoneal cavity, and is covered ventrally, as well as dorsally—except where the septum is continuous with the tissue of the lungs—by cœlomic epithelium. The interposition of the air-sacs between its two surfaces, does not, I believe, essentially alter the nature of the whole. My observations

entirely confirm Butler's conclusion, that "the avian diaphragm is seen to be completed as a single structure, and its separation into its two laminae is a secondary detail arising in connection with the development of the two pairs of intermediate air-sacs, which first penetrate it at a time when no distinct line can be drawn between the tissue that goes to form it, and that of the developing lung itself."

The adult arrangement of these structures is shown in text-fig. 32, p. 222, which is of a section of a Rook through the region of the liver and gizzard, seen from the ventral side. The post-pulmonary tissue is seen united to the lateral body-walls for a very considerable distance on either side, and ventrally and towards the middle line is pushed out irregularly into the peritoneal cavity by the growth within it of the posterior air-sacs. The latter, however, as I have already said, never project beyond the edge of the septum in which they lie, but always carry a layer of connective tissue and coelomic epithelium in front of them.

Text-fig. 30 is of a transverse section of a chick, 13 days after the beginning of incubation, through that part of the post-pulmonary

Text-fig. 30.



Transverse section of a chick of 13 days' incubation, through the region of the pericardium and anterior intermediate air-sacs; seen from behind.

septum which encloses the anterior intermediate air-sacs. The lungs are seen now lying in completely closed pleural cavities, separated from each other in the middle line by the median dorsal mesentery.

The post-pulmonary septum stretches across the coelomic cavity from one side to the other, closely fused to the lateral body-walls throughout its entire thickness. In it, near the middle line, lie the anterior intermediate air-sacs. The costo-pulmonary muscles pass inwards from the ribs dorsal to the air-sacs following the ventral border of the lungs. They really form a continuous layer dorsal to the oesophagus, but in the section figured they are interrupted by the ostia of the anterior intermediate air-sacs. Forming the ventral boundaries of the post-pulmonary septum are, medianly, the pulmo-hepatic recesses, and laterally, the abdominal cavity. Behind the pericardium at this stage the posterior intermediate air-sacs, still comparatively small, lie in the periphery of the septum, and more posteriorly the posterior air-sacs occupy the same position. These however have extended both ventrally and also towards the middle line, always carrying some tissue of the post-pulmonary septum with them, and have united with the median mesentery of the gizzard and liver, dorsal to these organs and ventral to the Wolffian bodies. This union forms the beginning of the post-hepatic septum to be described below. Text-fig. 31 is of a transverse section of the same chick of 13 days' incubation, taken through the region of the spleen, and showing the inwardly expanded post-pulmonary septum—containing the greatly enlarged posterior air-sacs—united to the gastro-hepatic ligament.

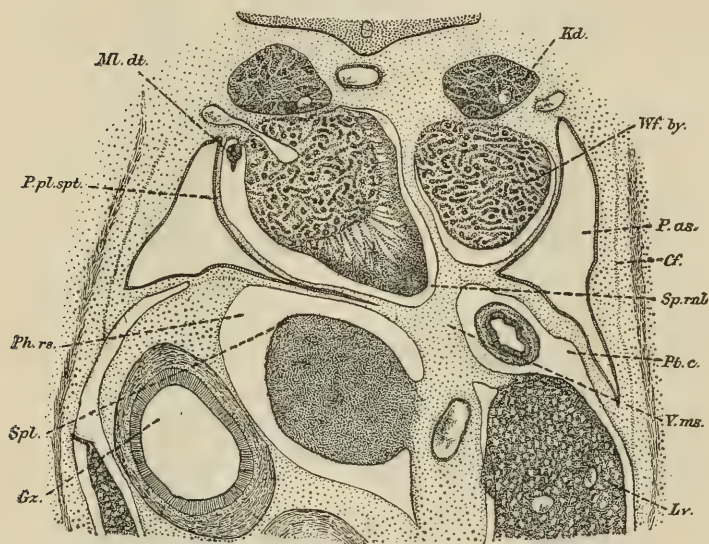
The Post-hepatic Septum.

This septum is completed in the chick on the 15th or 16th day of incubation. The first to be formed is the antero-dorsal moiety, and this is fully developed by the 13th day. Text-fig. 31, as I have already described, shows the formation of this part by the inward expansion of the two halves of the post-pulmonary septum (those parts termed by Butler the "oblique abdominal septa") towards the middle line, where they meet and fuse with the mesentery of the gizzard and liver. This lateral extension is due to the greatly increased size of the posterior air-sacs enclosed within the septum.

Ventral to this connection the gizzard is seen in text-fig. 31 included within the median mesentery, which is therefore split into two layers. Posteriorly this mesentery expands laterally before it becomes attached to the ventral body-wall; and at a later stage its lateral edges become fused to the side walls of the peritoneal cavity, thus constituting the postero-ventral portion of the post-hepatic septum. When fully formed, this is a membrane passing obliquely from the antero-dorsal to the postero-ventral walls of the peritoneal cavity and enclosing within its thickness the gizzard in the more posterior portion. It is a complete partition except on the left side where the dorsal and ventral components never quite meet, and so there remains always a narrow communication between the post-hepatic intestinal cavity and the

pulmo-hepatic recess of that side. Text-fig. 33, p. 223, shows very diagrammatically the divisions of the coelom in the adult bird in longitudinal vertical section. Text-fig. 34 is of a chick 17 days after the beginning of incubation, bisected longitudinally a little to the left of the middle line, and seen from the right side. The arrangement of the septa is the same as in the adult fowl but is shown more clearly, since in the latter the mesenteries are often loaded with fat. The gizzard is seen enclosed in the post-hepatic septum just dorsal to the attachment of the latter to the ventral body-wall, and in front of the umbilicus. Dorsally the septum is seen formed first by that part of the median mesentery which supports the spleen in the left pulmo-hepatic recess (see also text-fig. 31), and then by the post-pulmonary septum which is

Text-fig. 31.



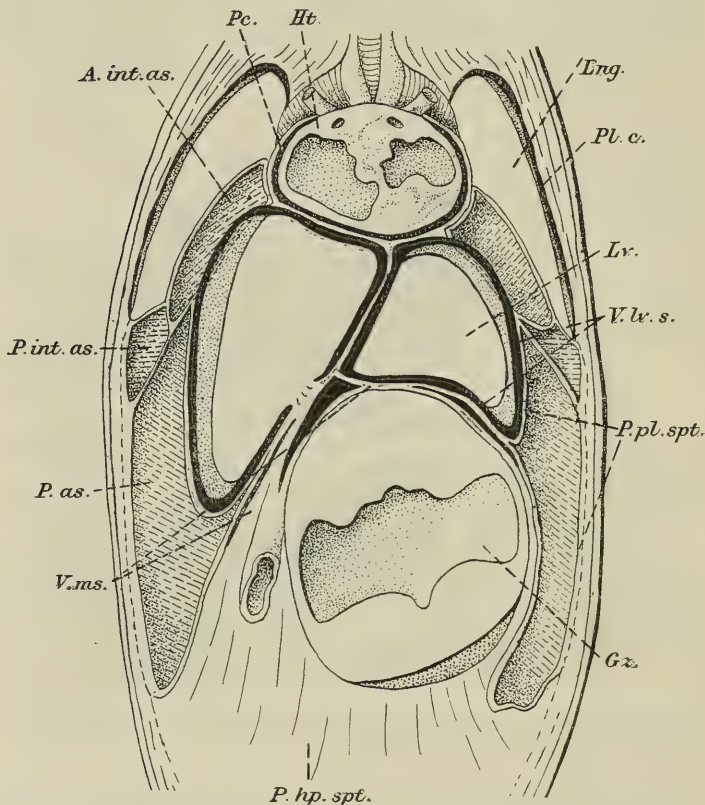
Transverse section of a chick of 13 days' incubation, through the connection between the posterior part of the post-pulmonary septum and the mesentery of the liver and gizzard; seen from behind.

itself united dorsally with the vertebral column by means of the median dorsal mesentery (see text-fig. 30, p. 219). By this time the air-sacs have increased so much in size, as completely to obliterate all the connective tissue of the post-pulmonary septum which at first surrounded and separated them from each other; and the walls of the adjacent air-sacs have become closely applied to each other. As a result of this, the post-hepatic septum appears in the figure to be completed dorsally by the posterior wall of the posterior intermediate air-sac together with the fused anterior

wall of the posterior air-sac. From an examination of the earlier stages, however, it is evident that the dorsal component of the post-hepatic septum is really formed by the whole of the more posterior portion of the post-pulmonary septum, with its contained air-sacs.

Text-figs. 32, 33, and 34 also show those peritoneal cavities, called by Butler the ventral liver-sacs, in which the two liver-

Text-fig. 32.

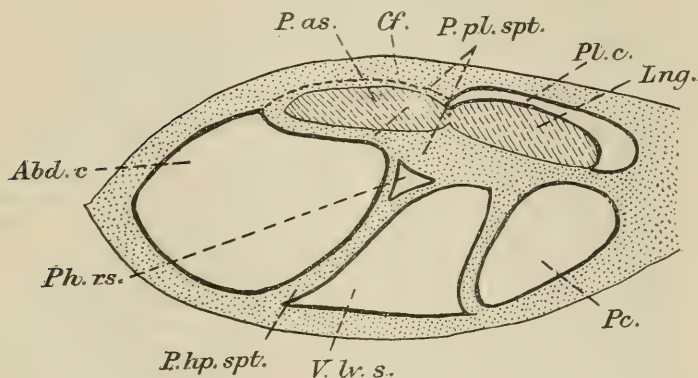


Adult Rook bisected horizontally through the region of the gizzard and liver-lobes, and slightly dissected anteriorly to expose the lungs; seen from the ventral side.

lobes are seen to lie upon opening a bird from the ventral side. These are clearly formed by no special development of septa, but are simply those parts of the peritoneal cavity which, by the ventral attachment to the body-wall of the post-hepatic septum, become shut off anteriorly between this septum and the posterior wall of

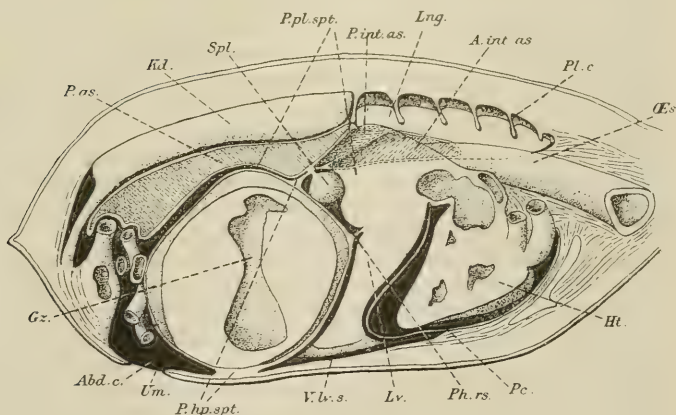
the pericardium. Their lateral walls are formed by the post-pulmonary septum, and the median partition between them is the ventral mesentery or falciform ligament.

Text-fig. 33.



Diagrammatic plan showing the subdivisions of the cœlom in a bird in longitudinal section.

Text-fig. 34.



Chick of 17 days' incubation bisected longitudinally a little to the left of the middle line; seen from the right side.

These figures show likewise that the pleural cavities persist even in the adult; though they tend to get somewhat obscured by the fusion here and there of the adjacent layers of pleural epithelium, and the development of connective-tissue strands across the cavities.

II. ADULT ANATOMY.

The Post-pulmonary Septum.

Bertelli [8] gives an extremely clear description, accompanied by an excellent drawing, of his "diaframma ornitico" in the Fowl, with the attachments of all the costo-pulmonary muscles. Since, however, Sappey [16] has given such an elaborate account of the whole post-pulmonary septum in the Duck, and Huxley [12] has done the same in *Apteryx*, I do not propose to go over the same ground again here. But as—in spite of the recent embryological work on the subject—there appears to be still some uncertainty as to the nature of the cavity within the post-pulmonary septum (that is to say between the pulmonary aponeurosis and oblique septum of Huxley), it may be as well to point out those parts of the descriptions given by Huxley and others which embryology has shown to be incorrect.

Huxley [12] in describing very clearly the partition which shuts off from the general visceral cavity a space enclosing the lungs and either most or all of the air-sacs on each side, apparently assumes, like Sappey, that this partition consists of two distinct septa, between which lies a cavity which is a division of the coelom. For between the pulmonary aponeurosis dorsally and laterally, and the oblique septum ventrally and posteriorly, the lateral body-wall and the median dorsal septum, Huxley describes a space which he calls the subpulmonary chamber. This, he says, "is divided into four loculi by three dissepiments, which pass transversely from the lateral face of the oblique septum to the mesial face of the pulmonary aponeurosis. Each loculus lodges one of the four postbronchial saccular diverticula of the wall of the lung, constituting the proper air-sacs, which thus fill up the subpulmonary chamber, between the insertion of the bronchus and its posterior extremity. . . . Thus, that part of the thoraco-abdominal cavity which lies dorsad and anterior to the oblique septum lodges no other viscera than the lungs and the air-sacs, and may be distinguished as the respiratory cavity, from the cardio-abdominal cavity which contains the heart and the rest of the viscera, and lies below and behind the oblique septum. The respiratory cavity is further divided into two lateral chambers by the median dorsal septum; and each of these chambers is subdivided by the pulmonary aponeurosis into two stories, of which the upper is occupied by the lung, and the lower by the loculi with their contained air-sacs." In the adult bird these structures do appear as above described, but from working out the development, it is at once clear that the cavity lying between the pulmonary aponeurosis and the oblique septum on each side, is not a division of the coelom lined by peritoneum, but merely the cavities of the three posterior air-sacs, and therefore lined by endoderm. The dissepiments which are described as subdividing the subpulmonary chamber into loculi, are only the walls of the same air-sacs, which by the growth of the latter have become

closely applied to one another, and so have obliterated the connective tissue of the post-pulmonary septum which at first separated them. The pulmonary aponeurosis and the oblique septum, as already shown, together constitute a single partition across the coelomic cavity, into the thickness of which the intermediate and posterior air-sacs push their way as they develop; the latter are never at any stage surrounded by a part of the body-cavity. Roché [15] and, in the last year, Müller [14] describe the subdivisions of the coelom in the same way.

Beddard [5] describes two interesting variations in the adult arrangement of the oblique septa. In the Emu, for example, he says, "the posterior part of the oblique septum is free from the abdominal walls, ending, in fact, in a free edge within the abdominal cavity, this edge being really continuous with the horizontal septum" (post-hepatic septum). This condition I believe to be due to the fact that in the Emu the posterior parts of the post-pulmonary septa fail to unite with the lateral body-walls, as they do in most forms, but retain throughout life the embryonic relations shown in text-fig. 29, p. 217. Beddard proceeds to say, "the oblique septum is thus merely a fold of the horizontal septum; they form one continuous structure." In the adult the two septa are really continuous, but it must be borne in mind that from its development only the anterior dorsal moiety of the post-hepatic septum is of the same nature as the post-pulmonary septum, the posterior ventral portion having a quite separate origin.

The other modification of the relations of the oblique septa occurs in many—and possibly all—Passerines. Here the septa of each side, "instead of being attached independently to the sternum, become fused with the falciform ligament in the middle line, and form a horizontal sheet of membrane covering over the two lobes of the liver. The original (?) attachments of the oblique septa are not, however, in these birds entirely lost; a much fenestrated membrane—sometimes, indeed, reduced to a thread or two—remains to remind the anatomist of the more prevalent conditions. In the Rook, however, they are completely preserved. But the attachment of the falciform ligament to the sternum in the middle line is lost." This condition of the oblique septa appears to be due to the backward growth, on the ventral side between the sternum and the pericardium, of diverticula of the median interclavicular air-sac. These in the adult seem to form a single sac, but are presumably of paired origin, since they open into the interclavicular air-sac by distinctly paired orifices; and Bertelli [7] has shown that this air-sac itself arises in the embryo as a double structure. These diverticula would seem to push their way behind the peritoneum lining the ventral body-wall, and so carry it inwards until it comes to invest closely the pericardium and liver-lobes, as Beddard shows to be the case in the adult bird. The persistence or not of the sternal attachments of the oblique septa would in this case be of no especial significance, since it

would depend only on whether, as in the Rook, the diverticulum remains comparatively slightly expanded laterally, and so only detaches the peritoneum from the body-wall in the middle line; or whether, as may be the case in other birds, it extends far round against the lateral body-walls into the post-pulmonary septa.

As I have before mentioned, I cannot agree with Bertelli's contention that the oblique septum, the "diaframma toraco-addominale," is not a septum, or part of a septum, at all, but "non è altro che la parete ventrale dei sacchi aeriferi intermedi e la parete posteriore del pericardio." He shows how in the Fowl the ventral walls of the air-sacs are covered by muscular tissue, and how in the Duck this is more markedly the case; but holds that the muscular tissue has nothing to do with the subdivision of the body-cavity, but belongs to the walls of the air-sacs, together with the nerves which, according to Beddard, are of spinal origin. Since, as I have shown, the air-sacs never project beyond the edge of the post-pulmonary septum, the muscles would lie in the connective tissue between the peritoneum bounding the abdominal cavity and the endoderm of the air-sacs, and therefore in the tissue of the post-pulmonary septum. And I believe that the presence of muscular tissue justifies the description of this part of the abdominal wall as the postero-ventral portion of the post-pulmonary septum.

Huxley [12] also describes a layer of muscular fibres in the oblique septum of the Duck, and Beddard [2] finds a considerable sheet of muscle in part of the septum of the Puffin (*Fratercula arctica*). He says: "This layer of muscular fibres arises from the pubis—from the proximal and larger half of this bone; it is abundantly furnished with blood-vessels and nerves. The direction of the muscle is oblique; it covers the hinder region of the oblique septum, ending abruptly some little way in front of the posterior attachment of the latter; it is attached below to the upper surface of the sternum, and to the abdominal parietes along the last sternal rib." Beddard also finds similar muscles in two species of Penguins (*Eudyptula minor* and *Spheniscus demersus*) and also, though feebly developed, in the Toucan (*Rhamphastos ariel*).

The Post-hepatic Septum.

This septum in the adult fowl is a membrane extending, as I have shown, obliquely across the visceral cavity from its dorsal to its ventral wall. Dorsally and laterally in front it is continuous with the post-pulmonary septum, which in turn is united with the vertebral column by means of the median dorsal mesentery. Posteriorly and postero-laterally it is attached to the ventral body-wall. It thus forms a complete septum, except on the left side where the pulmo-hepatic recess remains in communication with the abdominal cavity by means of a narrow aperture. Except for this orifice, the two pulmo-hepatic recesses now form

entirely closed cavities, lying between the post-pulmonary and post-hepatic septa, the alimentary canal and the liver. The post-hepatic septum passes dorsal to and behind the liver-lobes, and ventral to and in front of the intestines, and carries on its ventral surface the right anterior abdominal vein. The gizzard is enclosed within its thickness, in the ventral portion of the septum, and is thus completely shut off from the ventral liver-sacs, the posterior walls of which are constituted by the anterior peritoneal layer of the sheath of the gizzard.

This septum has been described in the Stork (*Leptoptilus*) and the Flamingo (*Phænicopterus antiquorum*) by Weldon [17], and in *Rhea*, *Struthio*, and *Dromæus* by Beddard [1]. In the Struthioness the liver-sacs are said to be closed off posteriorly from the space ventral to the post-hepatic septum, and this may possibly be compared with the condition found in the Crocodilia (see below). Beddard also describes the septum in Cranes and Hornbills, in the Penguin (*Spheniscus demersus*), in the Spur-winged Goose (*Plectropterus gambensis*), and in *Bernicla brenta*, where the septum bears a second (left) anterior abdominal vein which apparently corresponds to that occurring in reptiles, in the Grue (*Cariama*) and in many other birds; and I have myself observed it in the Golden Eagle. It probably therefore occurs throughout the entire group.

III. THE STRUCTURES POSSIBLY REPRESENTING THE AVIAN SEPTA IN REPTILES.

There are but few descriptions of the subdivision of the cœlum in the Reptilia, and these deal mostly with the adult anatomy; so that it is impossible to establish any homologies between these forms and Birds, in the almost complete absence of embryological evidence. I have therefore merely collected such facts regarding the subdivision of the cœlum in the various groups as may be of significance when more work on the development has been done.

In the Lacertilia generally there is no representative of either the post-pulmonary or the post-hepatic septum, but in many genera—*Lacerta*, *Iguana*, *Chamæleo*, and others—there is a well-developed pulmo-hepatic ligament, and consequently a pulmo-hepatic recess is formed on the right side [9]. This arrangement occurs again in *Sphenodon*, and is found of course also in Mammals [13]. In the Teiidae, however, Butler describes a well-developed post-hepatic septum in *Tupinambis teguexin*, and a slight approach to this condition in *Ameiva surinamensis* and *Callopiastes maculatus*, where the median ventral ligament is expanded laterally behind the liver, but does not become attached to the body-walls. In *Tupinambis*, however, the subdivision of the body-cavity into a pulmo-hepatic and an intestinal portion is almost complete except for a small aperture on either side. These are situated in the dorsal moiety of the septum, and hence Butler compares the latter with the ventral or omental part of the post-hepatic septum of birds; the absence of the dorsal portion in

consequence of the absence of air-sacs being indicated by the apertures in this region. That part of the septum which is present dorsally, he accounts for by the need of some such transverse membrane to carry the inferior vena cava to the liver, in the absence of the pulmo-hepatic ligament present in most other Lizards; and suggests that it may have been produced by the vena cava, instead of developing as in other Lacertilia and Birds in tissue continuous with the right pulmo-hepatic ligament, arising in a lateral expansion of the median dorsal mesentery.

In many species of *Monitor* and *Varanus*, Beddard [3] describes a horizontal (post-hepatic) membrane which covers the intestines when the body-wall is opened ventrally. He says it is attached anteriorly to the ventral body-wall in the middle line, and dorsally to the spinal column, while to the lateral parietes it is attached here and there by membranous bands. "It passes over the lobes of the liver and the stomach and shuts off the lungs from the abdominal cavity. The umbilical ligament dividing the two liver-lobes is present, and is attached to the dorsal side of the horizontal membrane. This horizontal membrane also separates the kidneys from the reproductive glands; the latter lie internally to it; the kidneys are placed outside it. . . . The fat-body when present lies below the membrane, and is therefore shut off from the abdominal cavity." Butler [11], however, describes how the fat-bodies in reptiles are typically placed outside the coelom and surrounded by distinct extra-peritoneal cavities—the circum-adiposal spaces. He therefore considers it probable that the greater part of this horizontal membrane described by Beddard is the lining peritoneum which has become almost completely separated from the abdominal walls by the great extension of the circumadiposal cavities outside it. This view as to the nature of Beddard's horizontal septum seems to be further borne out by the position of the umbilical ligament, which he describes truly as being attached to the dorsal surface of the membrane; for in birds and crocodiles, where I believe a real post-hepatic septum exists, the ligament is attached to the ventral surface, and thence passes to the ventral body-wall. Butler also shows that the position of the kidneys and gonads in relation to the horizontal membrane, is no proof of the septal nature of the latter; for the kidneys are entirely excluded from the coelom in crocodiles, birds, chelonians, and sometimes in lizards, while they lie well within the body-cavity in the Amphisbænidae; and in *Monitor niloticus* the posterior part of these organs lies within, and the anterior portion without, the peritoneal cavity. That part of the septum which shuts off the lungs from the abdominal cavity is, however, quite a separate structure, and appears to resemble more closely the condition seen in some Chelonia than in any other reptiles. The lungs of *Varanus* seem also to be so intimately connected with the dorsal body-wall, that all trace of a pleural cavity is lost, and this again happens in *Testudo* (see below). Or Butler suggests that the exclusion of the lungs from the peritoneal cavity may

take place in the Varanidæ as in snakes, by the gradual growth of connective tissue from the ventral surface of the lung round to the dorsal side so as to fill up any cavity that originally surrounded it.

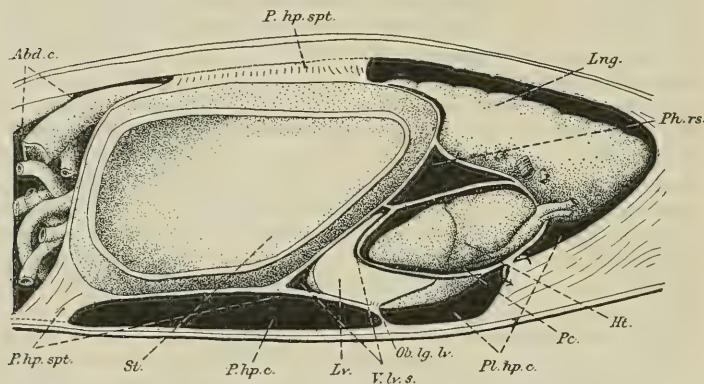
In the Chelonia, Bertelli describes the exclusion of the lungs from the general body-cavity by the development of a septum which he takes to be the homologue of the "diaframma ornitico." In the adult *Testudo græca*, this forms the ventral boundary of the lungs—round which it is fused with the lateral body-walls—as a layer of fibrous connective tissue covered by peritoneum. This condition is connected with that usually found among reptiles by intermediate stages, seen in *Thalassochelys caretta*, where this layer is very thin and does not completely shut off the lungs from the other viscera, and in *Emys lutaria*, where it is less developed, and the lungs for the greater part project free into the pleuro-peritoneal cavity. In an embryo of *Testudo*, 32 days after oviposition, the relations of the lung rudiments and the dorsal and ventral pulmonary ligaments are essentially the same as those in a chick of 72 hours' incubation (text-fig. 24, p. 212); and for some time development proceeds in the same way as in a bird, the lungs extending laterally and dorsally, the growth in the former direction tending to close off the pleural from the rest of the peritoneal cavity, and that in the latter to reduce the size of the pleural part of the cœlom. Later, the thick layer of tissue on the ventral surface of the lungs, which separates these organs from the underlying liver, meets and fuses with the lateral body-walls, and thus constitutes an almost complete septum across the peritoneal cavity. At the same time, the lungs unite with the dorsal and lateral walls of the pleural cavity so as to obliterate the cœlom in this region.

The diaphragm in *Testudo* is thus formed, according to Bertelli, out of the same constituents as is the diaphragm of birds, and has the same position and relations. Also the gradual obliteration of the pleural cavities takes place in the same way in the tortoise embryo as in the chick; although in the latter it is never complete, and there remains throughout life a narrow but distinct cavity bridged across here and there by strands of connective tissue. Since, however, the growth of the lungs in a dorsal and a lateral direction goes on at the same time, the obliteration of the cavity round the lungs, and the completion of the diaphragm, take place practically simultaneously; so that by the time the diaphragm is constituted in order to close off the pleural part from the rest of the peritoneal cavity, no pleural cavity remains. It appears, therefore, to be more likely that the condition seen in *Testudo* is to be compared with that occurring in the Varanidæ rather than with that found in Birds.

From the structure of several Crocodiles which I had the opportunity of examining, I believe that the arrangement of the cœlomic septa in this group of reptiles approaches most nearly to the avian condition, as Huxley and Beddard have already pointed

out [1, 2, 12]. Here the post-hepatic septum is well developed, and passes from its anterior dorsal attachment to the vertebral column, behind the liver-lobes and pericardium, to unite posteriorly with the ventral body-wall. As in birds, it encloses the stomach within its thickness, and carries on its ventral surface the anterior abdominal veins to the liver. It is attached to the lateral body-walls throughout its extent, so as to separate completely the pulmo-hepatic from the abdominal portion of the cœlom. Butler describes in a very young specimen a small passage between the abdominal cavity and the right pulmo-hepatic recess; but this presumably becomes closed at a later stage, for there was no such communication in the other animals which I dissected. The post-hepatic septum is apparently split secondarily in its ventral portion, and the flap thus formed on each side is closely applied to the liver-lobe so as to form a posterior wall to the liver-sac, and—together

Text-fig. 35.

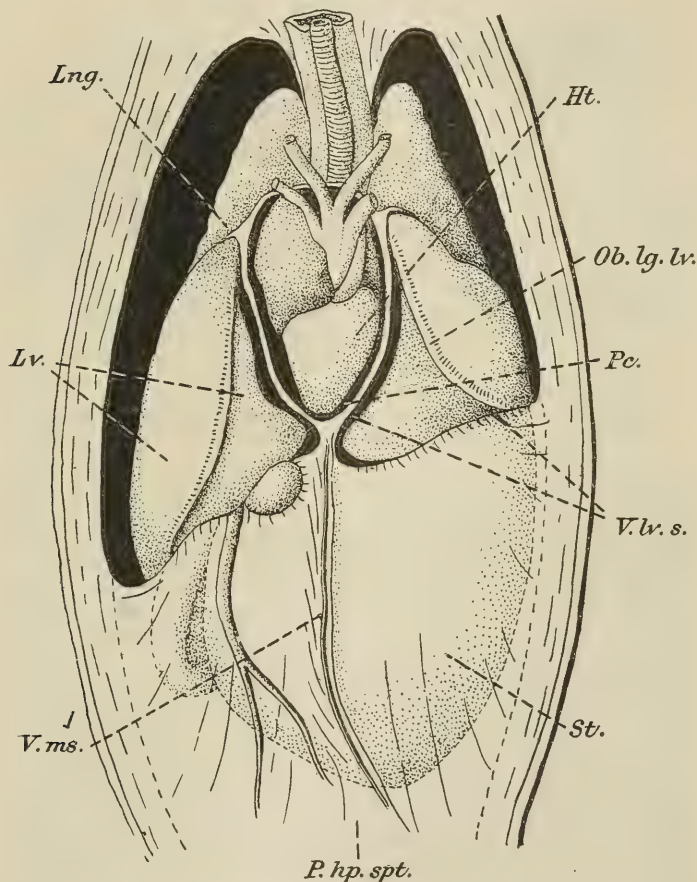


Young Crocodile bisected in the same way as Chick in text-fig. 34, p. 223.

with the oblique ligament of the liver with which it is connected—to shut off the pulmo-hepatic cavity from a subseptal, ventral, post-hepatic space. There is a large pulmo-hepatic cavity extending right round from the dorsal attachment of the post-hepatic septum to the ventral attachments of the oblique ligaments of the liver, perfectly continuous except for a narrow partition projecting a little way inwards from the ventral body-wall. The pulmo-hepatic recesses seem to correspond almost exactly to those spaces in birds, lying as they do between the ventral surfaces of the lungs, the dorsal margins of the liver, and the post-hepatic septum; and I believe that tissue which forms the roof of each recess, and covers the postero-ventral face of each lung, represents the post-pulmonary septum of birds. Text-fig. 36 is a dissection from the ventral side of a young specimen of *Crocodylus palustris*. It shows the continuous pulmo-hepatic cavities closed off behind

by the oblique ligaments of the liver and the more vertical portion of the post-hepatic septum. Nearer the middle line lie the ventral liver-sacs between the posterior wall of the pericardium, the oblique ligaments of the liver, the post-hepatic septum, and the median ventral mesentery. Behind, the post-hepatic septum

Text-fig. 36.

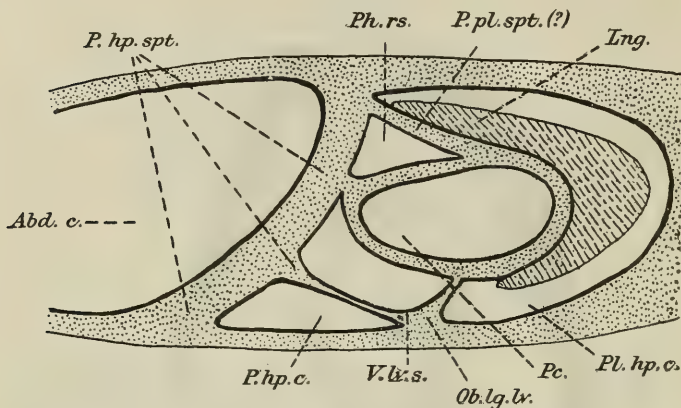


Young Crocodile opened from the ventral side. The ventral walls of the pericardium, pulmo-hepatic cavities, and ventral liver-sacs have been cut away.

lies horizontally over the stomach, attached both posteriorly and laterally to the body-wall (*cf.* text-fig. 32, p. 222, of a bird). Text-fig. 35 is of the same Crocodile bisected longitudinally a little to the left of the middle line. It shows, in addition to the structures seen

in the previous figure, the incomplete ventral partition between the pleural and hepatic regions of the pulmo-hepatic cavity, the position of the left pulmo-hepatic recess, and the possible representative of the avian post-pulmonary septum (*cf.* text-fig. 34 of a bird bisected in the same way, and also text-figs. 33, p. 223, and 37).

Text-fig. 37.



Diagrammatic plan showing the subdivisions of the coelom in a Crocodile in longitudinal section.

Huxley first called attention to the similarity between the arrangement of the coelomic subdivisions in Crocodiles and in Birds. He describes a fibrous expansion extending from the vertebral column "over the anterior face of the stomach, the liver, and the dorsal and front aspect of the pericardium, to the sternum and parietes of the thorax, separating the thoraco-abdominal space into a respiratory and a cardio-abdominal cavity, and representing the oblique septum of the bird. . . . A broad, thin muscle arises, on each side, from the anterior margin of the pubis; and its fibres pass forwards, diverging as they go, to be inserted into the ventral face of the posterior part of the pericardium and into the ventral and lateral parts of the fibrous capsule of the stomach, passing between that organ and the adherent posterior face of the liver, and being inserted into the fibrous aponeurosis which covers the anterior face of the stomach, and represents the oblique septum." This description appears to refer to the whole of that membrane which I have called the post-hepatic septum, together with the roof of the pulmo-hepatic recesses and the oblique ligaments of the liver; and as I have already said, it is only that tissue forming the roof of the pulmo-hepatic recess on each side which I regard as possibly comparable to the oblique septum (post-pulmonary septum) of Birds.

On the other hand, Beddard [2] says with reference to the muscles described by him in the oblique septa of Puffins and

Penguins, that the muscle referred to by Huxley in the Crocodile is the equivalent of this muscle, for in both cases the fibres arise from the pubis. Beddard therefore considers it more justifiable to identify the middle portion of the horizontal septum of the Crocodile with that structure in birds, while the lateral portions containing the muscles he compares with the oblique septa of birds. And this comparison he considers is made more obvious by the relations of the two septa in *Dromæus*; for here the oblique septa are not attached to the ventral body-wall, but posteriorly project with a free edge into the visceral cavity, appearing as a fold of the horizontal septum. This peculiarity in the Emu Beddard takes to support his contention that "the omentum (horizontal septum) as well as the oblique septa of birds are to be derived from the fibrous expansion which covers over the viscera in the Crocodilia." He also suggests that possibly "the oblique septum of birds has been produced by a vertical fold of this expansion." This does not seem to me likely however, as in development it is the oblique septa which are first formed, and only much later does the horizontal septum arise, partly as folds of the former. Also, against the above comparison of the lateral parts of the crocodilian horizontal septum with the oblique septa of birds, should I think be set the fact, that the only cause of the posterior attachment of the oblique septa in the latter being so far back as to bear a resemblance to the position of the lateral parts of the horizontal septum in Crocodiles, is the growth of the posterior air-sacs. But since these structures are not present in reptiles, we should expect to find the post-pulmonary septum but little extended, and comparable more or less to the embryonic condition in a bird (*cf.* text-fig. 25, p. 213) before the air-sacs are developed. And this is what we do find, if we take only that tissue on the ventral face of the lungs in the Crocodile as representing the avian post-pulmonary septum.

As to the origin and phylogenetic significance of the subdivisions of the pleuro-peritoneal cavity, it is impossible at present to say anything definite; for while on the whole the condition in the Crocodilia seems to approach most nearly that in Birds, yet the manner of the exclusion of the lungs from the peritoneal cavity in the latter is far more like that which occurs in *Testudo* and probably also in the Varanidæ. While again the post-hepatic septum—not represented in these two forms—is found, in the same way as in the Crocodile, in the Teiidæ, where it appears perfectly comparable to the more ventral portion of the avian post-hepatic septum; and according to Butler, it is also completely represented in Snakes. Therefore, whether or not the subdivision of the celom will prove of importance as to the phylogeny of the Reptilia and Aves, must, I think, remain undecided until further embryological work has been done.

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Photo. by Mr. Fingland.

SHELLS OF *PATELLA VULGATA*. $\times \frac{3}{4}$.

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EXPLANATION OF ABBREVIATIONS IN TEXT-FIGURES.

<i>Abd.c.</i> Abdominal cavity.	<i>P.hp.spt.</i> Post-hepatic septum.
<i>A.int.as.</i> Anterior intermediate air-sac.	<i>Ph.rs.</i> Pulmo-hepatic recess.
<i>Cf.</i> Line of fusion of cœlomic epithelium of post-pulmonary septum with that of lateral body-wall.	<i>P.int.as.</i> Posterior intermediate air-sac.
<i>Ct.pl.m.</i> Costo-pulmonary muscles.	<i>Pl.c.</i> Pleural cavity.
<i>D.ms.</i> Median dorsal mesentery.	<i>Pl.hp.c.</i> Pulmo-hepatic cavity.
<i>D.pl.lg.</i> Dorsal pulmonary ligament.	<i>Pl.r.t.</i> Pulmonary rudiment.
<i>Gz.</i> Gizzard.	<i>P.pl.spt.</i> Post-pulmonary septum.
<i>Ht.</i> Heart.	<i>P.p.p.m.</i> Pericardio-pleuro-peritoneal membrane.
<i>Kd.</i> Kidney.	<i>Prn.fld.</i> Pronephric fold.
<i>Lug.</i> Lung.	<i>Pt.c.</i> Peritoneal cavity.
<i>Lv.</i> Liver.	<i>Spl.</i> Spleen.
<i>Ml.dt.</i> Müllerian duct.	<i>Sp.rnl.</i> Supra-renal body.
<i>Ob.lg.lv.</i> Oblique ligament of the liver.	<i>St.</i> Stomach.
<i>(Es.)</i> Esophagus.	<i>Um.</i> Umbilical opening.
<i>P.as.</i> Posterior air-sac.	<i>V.lv.s.</i> Ventral liver-sac.
<i>Pc.</i> Pericardium.	<i>V.ms.</i> Median ventral mesentery.
<i>P.hp.c.</i> Post-hepatic cavity.	<i>V.pl.lg.</i> Ventral pulmonary ligament.
	<i>Wf.bdy.</i> Wolfian body.

2. The Growth of the Shell of *Patella vulgata* L.

By E. S. RUSSELL, M.A.*

[Received February 16, 1909.]

(Plate XXXII. †)

This paper consists of two parts; the first a study of the rate of growth of the limpet-shell, the second a study of the gradual change in the shape of the shell as it grows in size. Throughout the paper the *size* of the shell has been taken as a measure of its growth. Owing to the manner in which growth takes place, no dimension of the shell can increase without a corresponding increase in the other dimensions, so that any one dimension may be taken as a measure of growth, *i. e.* of increase in size. It is convenient to take length as a measure of size. Knowing the length one can calculate with a fair degree of accuracy all the other dimensions, if one has previously determined the average ratios of the other dimensions to length for successive values of the length.

I. RATE OF GROWTH.

1. *Breeding Season.*

The fact that limpets of 5 mm. in length may be found in January and in July leads one to suppose that the breeding season is of considerable duration, and the observations which I have made fully confirm this opinion.

I tried to discover at what time of year small limpets chiefly appear, by watching events in the small bay where I studied the growth of the limpet. On January 11th, 1908, there was a

* Communicated by Prof. J. ARTHUR THOMSON, F.Z.S.

† For explanation of the Plate see p. 253.

small proportion of 10–15 mm. shells and on January 25th there was seemingly a greater proportion of small shells 7–10 mm. in length. After that I have no records which indicate the settling down of very young limpets until July 21st, when I found that the small shells were mostly 15–25 mm. in length (and therefore simply the descendants of the 10–15 mm. long limpets of January), but that an occasional small one (8 mm.) occurred among them.

On August 4th at Millport I collected one or two tiny shells 2·5–3 mm. long from the crevices of a rock in the lower half of the beach. On September 2nd at the Cloch, Gourrock, there were visible in the bay a few 5–10 mm. shells, and on October 1st there were a few shells 8–12 mm. in length in places where they were not present on September 2nd.

From these data it would appear that the breeding-season extends from July to December or January. I examined also the gonad of a number of limpets at various times during the year.

On September 18th, 1907, three limpets were examined. Two of them were females, 28 mm. and 40 mm. in length, and the ovaries contained large but not quite ripe ova. In the 40 mm. long male the spermatozoa were fairly ripe. A number collected at the Cloch on December 25th, 1906, were quite ripe. Of 26 limpets collected at Cardwell Bay, Gourrock, on December 28th and 31st, 1907, 21 were males and only 5 were females. The males were not very ripe and some of them seemed spent, but the females had mature sexual products. Of five males collected at the Cloch on January 11th, 1908, only one was at all ripe, the others being spent. Ten limpets, 4 females and 6 males, were taken on February 8th. The males seemed spent and the ova in the gonads of the females were disintegrating. The breeding season is clearly over by the end of January if not a little sooner.

The sex of six limpets of 35–42 mm. in length collected on the 23rd May could not be determined with certainty, though they appeared to be males. The gonad was brick-red and only one-half to three-quarters its full size. At the anterior end it was beginning to turn cream-coloured, as if it were ripening into a mature testis in that region.

A male examined at Kames on July 2nd, 1906, had well-developed spermatozoa.

On July 11th, eleven limpets were examined. Six of them were females and their ovaries were at all stages of ripeness. One or two showed a number of fairly ripe ova, and the ovary had the typical olive-green tint which it shows when at all mature. The others were extremely unripe with very minute ova, and the colour of the ovary was a reddish-brown. The males were all moderately ripe. I attempted to carry out artificial fertilisation, and rather to my surprise obtained a number of early segmentation stages.

Artificial fertilisation was carried out with success at Millport on August 4th, early segmentation stages being again obtained.

Of 23 limpets collected at the Cloch on October 1st, 19 were males and fairly ripe, 3 were females also ripe, and 1 was immature, being only 20 mm. in length.

The breeding-season, therefore, probably lasts from about the middle of July to the middle of January. There is much individual variation as to the time of ripening, and so it is improbable that any single limpet is mature throughout the whole breeding-season. While the commencement of the breeding-season seems to be ill-defined, its finish is more definitely fixed.

Dr. J. F. Gemmill, who has examined the gonads of many limpets, tells me that he considers the limpet to be ripe from the beginning of November to the first fortnight of January. Davis and Fleure write (2. p. 59), "the season of sexual maturity is the autumn; Boutan finds it to be about September at Roscoff; at Aberystwyth we think it is somewhat later."

According to Fischer (3. p. 867) "la ponte s'effectue sur les côtes océaniques de France à la fin de mars et au commencement d'avril," which agrees well with the observations detailed above. It is probable that on our own shores the limpet is ripest during the months of October, November and December. A similar state of affairs seems to hold in the Adriatic, for Patten (8) obtained artificial fecundation of the eggs of *Patella* at Trieste in the beginning of December and the middle of January. At Naples, however, Wilson found the eggs of *Patella caerulea* in a mature state from March until June (12. p. 199).

Size at which maturity is reached.—From the examination of a large number of limpets (80–90) I find that sexual maturity is reached by the males at a length not less than 21 mm. I have found immature males during the breeding-season 16·5, 19·5, 20, and 21 mm. long. The gonad grows with the animal, and in males 21–30 mm. in length it is only about half its ultimate size. It is fully developed at about 40 mm.

I have seen no female smaller than 26 mm., but at that length the limpet may have mature ova. The ovary attains its full size in limpets of about 40 mm. in length.

According to Dr. Gemmill's observations limpets may be mature as small as 18–20 mm.

It is of interest to compare the closely allied *Acmæa* with *Patella* in this respect. In *Acmæa* (the breeding-season of which lasts from the middle of April to the end of July) sexual maturity is attained under 10 mm. long and probably after one winter (Willcox, 11).

Another interesting example from among the Gastropoda of a very rapid attainment of sexual maturity long before adult size is reached is to be found in Semper's 'Animal Life' (p. 126). Land snails in the warm regions round the Mediterranean are brought to sexual maturity when only six months old by the heat and moisture of the spring. They are then by no means full-grown.

Proportion of the Sexes.—Out of 87 limpets examined, 66 were

males and 21 females. They were collected for the most part near Gourrock. The males are apparently about three times as numerous as the females in this locality, while at Millport Dr. Gemmill (5. p. 394) found that of about 250 limpets examined 68 per cent were females. From some old observations by Lebert and Robin (6) it appears that in their experience there were about three males to eight or ten females. It would be interesting to discover the reason for this great variation in the proportion of the sexes.

2. Growth Data.

In order to study the rate of growth of the limpet throughout the year I marked a considerable number on December 31st, 1907, in a bay near the Cloch, Gourrock, and attempted to keep full records of their growth from month to month during 1908. A number of them of course disappeared during the year, but their places were filled by others; for example on May 25th and May 30th, I measured about two dozen small-sized limpets and kept many of them under observation until the end of the year.

The detailed records are given in Table I. where they are arranged in year-groups, and more or less in order of magnitude in each group. M = mean value.

The possibility of arranging the measurements in year-groups, at least for the first two years, arises from the fact that the breeding-season of the limpet, though a very long one, is fairly well-defined.

TABLE I.—*Growth-Data, arranged in Year-Groups.*

1908 brood, Oct. 31, 11·5 mm. Nov. 30, 13 mm.

FIRST YEAR-GROUP (1907 brood).

	1907 Dec. 31.	1908 Jan. 25.	Feb. 8.	Mar. 14.	Apr. 14.	May 23.	May 25.	May 30.	June 27.	July 30.	Sep. 2.	Oct. 1.	Oct. 31.	Nov. 30.	Dec. 31.
1...	9·6	10·2	12	14·5	...	...	18·7						
2...	...	10	...	...	11·9	14·5									
3...	10·4	11	12·5	15·3	...	...	18·9	19·8	23·7	26	27·6		
4...	10·5	11·5	13·1	16·8	...	...	21·5	23·8	27·1	31			
5...	11·1	12	...	16·4	...	...	20·8	22·6	26·3	28	29·3		
6...	10·3	13	14·9	19·1				
7...	10·9	...	14	16	...	20·2	21	21·1	
8...	12	...	14·5	17·1	20	22	23		
9...	11·9	14·9	18·2	20·8	22·5			
10...	11·6	...	15						

FIRST YEAR-GROUP (1907 brood) (*continued*).

	1907 1908															
	Dec. 31.	Jan. 25.	Feb. 8.	Mar. 14.	Apr. 14.	May 23.	May 25.	May 30.	June 27.	July 30.	Sep. 2.	Oct. 1.	Oct. 31.	Nov. 30.	Dec. 31.	
11...	10.8	...	15	20						
12...	13	15.1	18.4	21.9	24.3				
13...	13	...	15.8	18.3	21.9	24.3	26	27.3	27.3	
14...	13	...	16	18.8	22.4	25				
15...	14.4	...	16.4	19.1	21	23.4	24.5	26.2	27	
16...	14.5	16.6	17	20	22.9	24.5	24.5	24.5	
17...	14	16.9	21	24	26.4	27.2	27.8	28	
18...	13.3	...	16.9	20.9	23.5	25.8	27.1			
19...	13	...	17.1	21.9	24.5	27.8	29	29.8	30	
20...	15	...	...	19	21.3					
21...	15.5	...	17.7	21	24.5	26.4	28			
22...	16.1	18.5	22	25.4	26.5	27.9	28.7	28.9	
23...	16	19	21.5	24.7	26.8	29	29.9	29.9	
24...	18	19.2	22.8	25	27.5	28.9	29.1	29.7	
25...	16.4	...	19.5	23	26.6	27.8	28.5	29.2	29.2	
26...	17	...	19.5	23	26.8	28				
27...	15.9	...	19.7	24	26.1	28.5	29.9	30.5	31	
28...	16.8	...	19.9	21.1	22.1	23	23.2	25	25	
29...	19.6	...	22	25.4	27	28.1	28.8	29.2	29.2	
30...	18.8	22.1	24.1	28	29.3	30.9			
31...	19.8	23.5	27.2	30.5	32.8	33.1	33.8	33.8	
32...	14	14	15.2	18										
33...	14.2	14.6	16.7	18.9	...	...	21.7	25.2	28.2	31	32.4	34.5		
34...	15.3	16.5											
35...	25.1	26.1	27.3			
36...	29.5	30.9			
37...	17.6	18.2	18.6	22	...	...	24.2							
38...	18.8	19.9	21	...	...	24.5	27.8	29.8	31.6	...	...	33.4	
39...	21	22.5	...	...	25.3	...	28.7	29.5	30.5			
M...		15.5		18.6	21.2	24.5	26.7	27.8	28.4	29.1	

SECOND YEAR-GROUP (1906 brood).

	1907 Dec. 31.	1908 Jan. 11.	Feb. 8.	Mar. 14.	Apr. 14.	May 23.	June 27.	July 30.	Sep. 2.	Oct. 1.	Oct. 31.	Nov. 30.	Dec. 31.
40 ...	...	21	21·8	22·2	23·1	23·6	26·7	28·6	30·4	30·8	32·4	32·5	33·5
41 ...	...	21·3	22·1	22·2	23	24·3	26·2	27	28				
42 ...	...	23·7	25·1	25·5	26·2	26·6	27·8	29·3	30	31			
43 ...	22	...	22										
44 ...	22·5	...	23	24·1	25·6	26·8	29·1	31·2	34·4		35·3		
45 ...	23·8	...	24·1	24·6									
46 ...	25·5	...	26	26·9	27·2	28·4	29·8	32·9	35·6	36·7	37	37	37
47 ...	27	...	27	27·5	28·2	29	30·8	33	34·2	34·8	35·2	35·2	35·3
48 ...	27·9	...	...	...	28·8								
49 ...	...	27·2	27·7	28	28·5	28·5	30·2	30·8	31	31·2	33	33·3	33·6
50 ...	29	...	29	30	31	31·1	31·8	34	36	36	37	37·2	38
51* ...	...	...	29·1	...	...	32	34·5	...	37·9	39·5	40		
52 ...	29·2	...	29·9										
53 ...	...	...	29·9	...	30·5								
54 ...	30	...	31	...	...	32·9	34	36·9	38	38·9	38·9		
55 ...	30	...	...	...	...	33·4	35·4	37·9	39·2	40·5	42	42·2	42·2
56 ...	30·5	...	31	...	32	32·9	32·9	35	37·8	39	39	39	39
57 ...	...	...	32·5	32·8	33·6	34·5	37·4	40·8	42	42	42	42	42·2
58 ...	...	32·4	32·8	33·6	34	35	37·6	40·1	40·9				
59 ...	...	32	33	33	33·3	34							
60 ...	32·6	...	33	33	34	34·8	36·5						
61 ...	33·4	...	34·2										
62 ...	33·5	...	...	34	35	35·7	36·9						
63 ...	34·4	...	35·9										
64 ...	...	...	...	...	...	36·8	38·4	...	40·8	41	41	41	41
65 ...	...	...	...	...	...	...	...	...	40·6	40·8	41	41	
M ...	28·8	...	28·6	28·4	29·6	31·1	32·7	33·7	36	37·1	38	38	38

* No 51 measured 23·5 mm. on 7th Sept. 1907.

THIRD YEAR-GROUP (1905 brood).

	1907 Dec. 31.	1908 Jan. 25	Feb. 8.	Mar. 14.	Apr. 14.	May 23.	June 27.	July 30.	Sep. 2.	Oct. 1.	Oct. 31.	Nov. 30.	Dec. 31.
66 ...	36	...	36	...	37.1	38.7	40.1	...	43.8	44	45		
67 ...	36.4	...	...	37.9									
68 ...	36.7	...	36.9	...	37.2	37.9	38.9	38.9	38.9	38.9	39	40	40
69 ...	38.1	...	...	39	39.5	40	41						
70 ...	...	37	...	37.5	37.5								
71 ...	...	...	...	...	...	...	...	...	42	43	43.2	43.2	43.2
72 ...	...	...	...	...	...	...	...	...	43.2	44	44	44	44
73 ...	...	...	...	...	...	...	...	...	44	45.5	45.5		
73a...	...	...	...	...	...	40	41	...	42.8	43.5	43.9	43.9	43.9

FOURTH YEAR-GROUP (1904 brood).

	1907 Sept. 7.	Dec. 31.	1908 Jan. 11.	Feb. 8.	Mar. 14.	Apr. 14.	May 23.	June 27.	July 30.	Sep. 2.	Oct. 1.	Oct. 31.	Nov. 30.	Dec. 31.
74 ...	43.5	46.8	...	46.8	47.1	47.4								
75 ...	...	43	...	43.9	44	44								
76 ...	43.6	46	...	46	...	46	46	47	...	47.9	48	48	48.1	48.1
77 ...	45.7	46	...	46	46									
78 ...	...	...	45	45	45.5									
79 ...	46.5	...	...	47	47	47.6								
80 ...	...	...	...	...	...	...	...	...	47.4	47.5	47.5	47.5	47.5	47.9
81 ...	...	...	...	...	...	...	...	...	49.2	49.2	49.3	49.3		

FIFTH OR SIXTH YEAR-GROUP (1903 or 1902 brood).

82 ...	...	50	...	...	50	50	50							
83 ...	50	50.5	...	50.5	51	51.4	52	52.2	...	52.5	52.5	53	53.5	53.5

First Year-Group.—It is a curious fact that one rarely finds on the shore limpets less than say 7 mm. long. I have found them of

5 mm., 4 mm., and 2.5 mm. in length, but such small limpets are distinctly rare. They are of course extremely inconspicuous. In the autumn and during the winter limpets of about 10 mm. long gradually appear on the shore, settling down in greatest abundance in the months of January and February. There seems no reason to doubt that such limpets are only a few months old, and represent the first year-group. As the tables show they grow very rapidly (see Tables I. and V.) and can have taken only a few months to reach the length of 10 mm. It should be noticed that in very small limpets (2—3 mm.) the shell is very much larger in proportion to the animal than in older limpets. If these limpets of about 10 mm. length represented not the first but the second year-group there ought to be found on the shore in spring and summer great numbers of shells from about 3 mm. to 7 mm. in length, and this is quite certainly not the case. Nor does it seem likely that the free-swimming larval life of the limpet is very long, or indeed longer than a week or two, for in the allied *Acmea virginea* the pelagic life is limited to a few days (Boutan). *Acmea testudinalis*, a much smaller shell than *Patella vulgata*, breeds from April to July and the season's young are 4–5 mm. long in October (Willcox, 11).

A random sample of 1003 limpets taken in July 1903 and 1904 at Southend, Arran, show very clearly that this group of shells about 10 mm. long in January is really the first year-group. The sample was taken just at the very beginning of the breeding-season so that only a very few of the season's young were included.

TABLE II.

Random Sample in month of July.

Size in mm.	No.	Size in mm.	No.
3—5.5	5	36—38.5	60
6—8.5	9	39—41.5	50
9—11.5	26	42—44.5	65
12—14.5	72	45—47.5	91
15—17.5	102	48—50.5	83
18—20.5	97	51—53.5	77
21—23.5	55	54—56.5	39
24—26.5	38	57—59.5	12
27—29.5	41	60—62.5	4
30—32.5	41	63—65.5	1
33—35.5	34	66—68.5	1

The first year-group revealed by these figures has its mode clearly in the fifth class (15–17.5 mm.). Leaving out the first class (3–5.5 mm. shells), which represents probably the first of the season's brood, and taking the next seven we find that the mean value is 17.53 mm., indicating that limpets of the last season are

now in July of an average length of 17-18 mm. These facts taken together seem to warrant us in placing in the first year-group the limpets, Nos. 1-5 (Table I.). These reach a length of about 15 mm. by the third week in May. Nos. 6-31 form a natural group, since they were all found in a small area of a few square yards and present no abrupt difference in size. Nos. 6-23 are quite clearly of the same year-group as Nos. 1-5, and it seems safe to include also in this first year-group Nos. 24-31 and 32-36. No. 29 for example, though 19.6 mm. long on May 25th, is only 29.2 mm. long on Dec. 31st, a length which is reached on that date by No. 25 which was only 16.4 mm. long on May. 25th. One must allow for a good deal of variation in the rate of growth as well as for the fact that each year-group may include limpets differing as much as six or seven months in age, since the breeding-season is of that length. Nos. 27 and 28 illustrate how one limpet may differ from another in rate of growth, so also do Nos. 3 and 4. On the other hand the rate of growth often exhibits surprisingly little variation, as is shown by Nos. 12, 13, and 14, 17 and 18, 24 and 25, and others.

The placing of Nos. 37, 38, and 39 in the first year-group is a little doubtful, but is I think on the whole justifiable.

The mean values have been calculated from the month of May onward, and from them we can infer that a limpet which has come into existence say in September will reach a length of about 15 mm. in the following May, 18 mm. in June, 20 mm. in July, 24 mm. in August, 26 mm. in September, 27 mm. in October, 28 mm. in November, and by the end of the year will attain on an average a length of 29 mm.

These figures are of course only roughly approximate and are valid only for the particular locality where the limpets grew. Limpets at the Southend of Arran seem to reach a length of only 17-18 mm. by the month of July.

Second Year-Group.—Given the first year-group it is a simple matter to determine the second year-group. On December 31st, 1908, the first year-group had a certain range and a certain mean value, and the second year-group must necessarily have had on December 31st, 1907, approximately the same range and the same mean value. The limpets assigned to the second year-group (Nos. 40-65) have been selected on this principle. Their range of size on December 31st, 1907, is from 22 mm. to 34.4 mm., and their mean 28.8 mm. The mean value of the first year-group on December 31st, 1908, was 29.1 mm. and the range from 24.5 mm. to 33.8 mm., but if No. 7 had survived till December 31st the range would have been from about 21.5 mm. up to 33.8 mm. The average size on December 31st, 1908, in this year-group is 38 mm.

Subsequent Year-Groups.—It is not possible to arrange the limpets of 35 mm. long and upwards in year-groups with any certainty. The arrangement adopted above seems the most satisfactory, but it is only tentative.

3. Variation in Rate of Growth with Increase in Size.

The rate of growth decreases with increase of size. This fact is shown by the data already given, but in order to gain a precise knowledge of the manner of the decrease it is necessary to discount the possible influence of time of year and temperature upon the rate of growth. This has been done by taking the figures given in Table I., for the period July 30th to September 2nd, and considering along with them some other additional data which have reference also to the month of August. These are, (1) observations on the growth of 10 limpets at the Cloch, Gourrock, from the end of July to the second week in September 1906 (43 days), and (2) on a similar number at the same place from July 31st to September 7th, 1907 (38 days). A few additional data referring to seven limpets at Kames, during July 1906, are also incorporated. The detailed observations are given in the following Tables.

TABLE III.

Growth during 43 days. The Cloch, Gourrock, Aug. 1906.

Group.	Original size.	Final Size.	Growth per cent. in 30 days.
20—25 mm.	20·6	25·5	16·59
	21	27	19·93
	23·4	27	10·73
25—30 mm.	25	27·7	7·53
	26	29·5	9·41
	26·5	28	3·95
	27	31·2	10·85
40—45 mm.	42·2	45·5	5·46
	44·6	45	·62
45—50 mm.	46	46·5	·76

TABLE IV.

Growth from July 31 to Sept. 7 (38 days). The Cloch, Gourrock.

Group.	Original Size.	Final Size.	Growth per cent. in 30 days.
15—20 mm.	16·4	21·9	26·48
	18	21	13·16
	19·8	23·5	14·75
35—40 mm.	39·1	43·6	9·08
40—45 mm.	42·5	43·5	1·85
	43·5	45·7	3·99
45—50 mm.	46·2	47	1·37
	46·5	47·5	1·69
	46·8	47·4	1·01
	49·7	50	·48

TABLE V.

Growth during July 1906 at Kames, Kyles or Bute.

Group.	Original Size.	Final Size.	No. of days.	Growth per cent. in 30 days.
0—5 mm.	4	5	25	30·00
5—10 mm.	{ 5·5	6	25	10·91
	{ 8·5	10·5	31	22·77
10—15 mm.	{ 10	13	25	36·00
	{ 13	15	25	18·46
	{ 11·5	13	31	12·62
	{ 12	12·5	31	4·03

The observations recorded in Table I. amount to 42 for the month of August.

The mean values calculated are given in Table VI.

TABLE VI.

Rate of Growth and Size.

Group.	No.	Growth per cent. in 30 days.
0—5 mm.	1	30·00
5—10 "	2	16·84
10—15 "	5	19·20
15—20 "	12	15·56
20—25 "	17	12·42
25—30 "	11	6·89
30—35 "	5	5·05
35—40 "	5	4·77
40—45 "	6	2·71
45—50 "	5	1·06

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The percentages in the first two groups cannot be taken into account since the numbers are so small. From 10 mm. on to 25 mm. there is a gradual and uniform falling-off in the rate of growth. In the 25–30 mm. group there is a sudden fall of the rate to little more than half what it was at 20–25 mm., then there is another gradual decrease up to the length of 50 mm. There is a second slightly marked fall at a length of about 40 mm.

4. Seasonal Variation in Rate of Growth.

That the limpet grows more quickly in the warmer months of the year is a fact which is clearly shown by the data in Table I. In the first year-group for example, during the months of June, July, and August, the monthly increment of growth is about 3 mm. During September the increment is 2·2 mm., during

October 1.1 mm., during November .6 mm., and during December .7 mm. The percentage increase falls even more rapidly.

But it is in the second year-group (where there is little variation in the rate of growth due to age) that the seasonal variation is shown most clearly. During the first three months of the year growth is practically at a standstill, then during the summer a slow increase in size is manifested, but after October growth almost ceases again. It should be remarked in passing that the jump from 33.7 mm. at July 30th to 36 mm. at September 2nd does not signify that growth is specially active during August. The increase is due to the introduction into the group on September 2nd of the large shell No. 65 and to the reappearance of No. 64.

The seasonal variation in the rate of growth may be proved in another way. In Table VI. the percentage growth during the month of August is tabulated for limpets of all sizes.

It is easy to calculate from these data the number of days which a limpet would take to grow from 10 mm. to 15 mm., from 15 mm. to 20 mm. and so on, if it grew as quickly during the other months of the year as it does during August. Using the formula

$$O\left(\frac{100 + P}{100}\right)^n = F,$$

where O = original length, F = final length, P = percentage increase per 30 days, and n = number of months (of 30 days) taken to grow from O to F , we obtain the following results:—

Time taken to grow	Days.	Sums.
from 10 mm. to 15 mm.	69.26	69.26
15 " 20 " 	59.71	128.97
20 " 25 " 	57.18	186.15
25 " 30 " 	82.08	268.23
30 " 35 " 	93.87	362.10
35 " 40 " 	100.77	462.87
40 " 45 " 	132.15	595.02
45 " 50 " 	306.33	901.35

Suppose we start with a shell which is 10 mm. long on January 1st. If growth during the first two or three months is as rapid as it is during August, the shells in the first year-group should be 15 mm. long on March 10th, 20 mm. long on May 9th, 25 mm. long on July 5th. But actually, as is shown in Table I., they reach a length of 15 mm. only by the end of May, and 20 mm. some time towards the end of July. Hence growth during late winter and early spring is slower than during autumn. The same method might be applied to show that growth is again retarded on the approach of winter, but one more application of the method will suffice. If we take the second year-group and start with a shell 30 mm. long on January 1st, it will, if it grows at summer rates, reach a length of 35 mm. on April 4th,

40 mm. on July 14th, and 45 mm. on Nov. 23rd. But actually the second year-group attains to a length of only 38 mm. even by December 31st.

5. *Rate of Growth and Reproduction.*

We have seen that the variations in the rate of growth of the limpet's shell depend upon the age of the shell and upon the temperature. It is natural to enquire whether the attainment of sexual maturity has any marked effect upon the rate of growth. In other words, does arrival at a state of maturity coincide with any marked drop in the rate of growth? It would seem that it does, for sexual maturity is attained between 20 mm. and 25 mm., and there is a marked fall of the rate of growth at 25 mm. to half what it was at about 20 mm. Growth, however, continues for long after a length of 25 mm. is reached, and ceases only at 50-60 mm. The average full-grown size is about 45-50 mm. The limpet shell therefore doubles its length after sexual maturity has been reached. This fact recalls the law of growth which Dr. Fulton has formulated for fish, that they "approximately double their size and increase their weight about eight times after they have reached sexual maturity." (4. p. 182.)

After the attainment of sexual maturity the shell becomes much thicker and more solid in build. This increase in thickness is no doubt correlated with its slower growth.

6. *History of the Growing Limpet.*

The facts detailed above enable us to form a mental picture of the life-history of the limpet once it has settled down upon the shore as a miniature adult.

It may come into existence at any time from July to January. Its larval existence lasts probably only a week or two and it settles down as a minute shell, one or two mm. in length. Growth is rapid during the autumn. By January the shell is on the average about 10 mm. long, and during January and February it grows say 2 mm. The rate of growth is then accelerated, and growth continues actively throughout the summer. In August or September the limpet, which is now 20-25 mm. in length, becomes sexually mature. The rate of growth, which has hitherto been anything from 12-20 per cent. per month, now falls abruptly on the approach of winter and after the ripening of the gonad. By the month of December the limpet is on the average 29 mm. long. Very little increase of size is manifested during the early months of the second year, but by April a slow growth sets in at the rate of 5-7 per cent. per month, which falls off after the summer is past to 1-2 per cent. and finally in the early winter months ceases almost completely. During this year the gonad has undergone profound changes, returning in the early spring to a state almost of primary indifference and gradually ripening as the summer advances. The gonad attains its full size in this

second year, at the end of which the limpet is about 38 mm. long. The sequence of events during the third year is probably very similar to what it is in the second. Growth is even slower, and the limpet may increase only 5 mm. in length. The limpet possibly becomes full-grown at the end of this third year or at the end of the fourth year—at a length of a little more than 45 mm. Growth is almost at a standstill during the fourth year, and shells of 48 mm. and upwards may exhibit for long periods no growth at all, so that their age may be considerably more than four or five years.

The distribution of lengths in a large random sample (Table II.) shows that the limpets are subject to a considerable degree of elimination, the numbers in the first year-group (say 9–23·5 mm. for the month of July) being much greater than the numbers for the second year-group (say 24–38·5 mm.). The third and subsequent year-groups are not shown separately by a random sample but merge into one another. The great number of shells 45–53·5 mm. long which occur in the sample show that growth at this size is practically stationary, for shells of this size represent several different year-groups.

It is of interest to compare the life-history of the Tortoiseshell Limpet, *Acmea testudinialis*, as related by Willcox (11). It shows much analogy with that of *Patella vulgata*. *Acmea testudinialis*, it should be mentioned, reaches a length of only some 20 mm.

The breeding-season in America lasts from the middle of April to the end of July. Boutan (1) says that “la ponte de l'*Acmée* a lieu en avril et en mai” on the French coast, and I have reason to think that the same holds for the *Acmea* of the Clyde. Willcox finds that the young *Acmea* are 4–5 mm. long in September and early October, and that they attain sexual maturity under 10 mm., probably after one winter.

In Plate XXXII. the first two rows show stages of about fifteen months' growth, the second and third limpets in the second row showing the size at which sexual maturity is reached. The first two in the third row show the size of second year shells, the second (38·5 mm.) being from two to two and a half years old. The first limpet in the fourth row is probably a little more than three years old, while the other two in the row are full-grown limpets at least four to five years old. The two in the bottom row are veterans, the last one (61·2 mm. in length) being the largest limpet I have ever collected.

II. CHANGES IN SHAPE DURING GROWTH.

About 1000 shells were collected at random during July 1903 and July 1904 at the Southend of Arran, and the ratios of the various dimensions calculated for every shell.

Table VII. gives the mean ratios in each group; L stands for length, B for greatest width, H for height, Ab and Af are explained a few lines further on

TABLE VII.

Mean Ratios.

Group.	No.	$\frac{L}{B}$	$\frac{Ab}{Af}$	$\frac{L}{H}$	$\frac{H}{B}$
5-10 mm.	21	1.32	1.64	3.52	.375
10-15 "	109	1.29	1.57	3.68	.352
15-20 "	163	1.27	1.46	2.95	.431
20-25 "	91	1.25	1.44	3.33	.375
25-30 "	63	1.23	1.36	3.11	.395
30-35 "	68	1.21	1.34	2.87	.422
35-40 "	81	1.19	1.31	2.65	.449
40-45 "	115	1.17	1.26	2.45	.478
45-50 "	138	1.16	1.24	2.28	.509
50-55 "	122	1.15	1.22	2.16	.532
55-60 "	25	1.15	1.17	2.28	.504

As is shown in Table VII. very considerable changes take place in the shape of the limpet-shell during its growth from 5 mm. to 60 mm. long.

$\frac{L}{B}$.—The shell becomes gradually broader in proportion to its length, and this change is remarkably uniform from group to group.

$\frac{L}{H}$, $\frac{H}{B}$.—It grows higher in proportion to its length and in proportion to its breadth. This change is on the whole a continuous one, but a reversal of its direction in both cases takes place in the transition from the first to the second, from the third to the fourth, and from the second last to the last groups.

$\frac{Ab}{Af}$.—The distance in a straight line between the apex and the anterior margin (Af) becomes greater with great uniformity in proportion to the distance between the apex and the posterior margin (Ab). It does not follow that the apex shifts backwards. The changes in the position of the apex may be represented graphically if the successive values of the ratios $\frac{L}{H}$ and $\frac{Ab}{Af}$ are drawn to scale on a constant L. It appears from such figures that the apex of the shell shifts gradually backwards during growth from 5 mm. to 25 mm., and then remains practically stationary till a length of 55 mm. is reached, when it again shifts backwards.

Most of these changes can be directly inferred from the shape of a typical fully-grown limpet-shell. A small limpet-shell has the shape of a flattened excentric cone, and the apex is in such a young shell finely pointed and turned forwards. As growth proceeds the sides of the cone do not grow straight on, but begin to curve inwards slightly, so that by the time the shell reaches a length of 50 mm. its outline as seen from the side may be such as is shown in the Plate (last row). All good-sized limpet-shells show this "ingrowth" in the anterior and posterior regions of the shell, and also at the sides of the shell, for a similar "ingrowth" takes place there also. This general "ingrowth"

accounts for the decrease of the ratio $\frac{L}{H}$ and the increase of the ratio $\frac{H}{B}$. The change in the ratio $\frac{Ab}{Af}$ is chiefly due to the same cause, and especially to the fact, easily observed, that the "ingrowth" at the posterior margin is much greater in extent than it is at the anterior margin, whence it arises that Af becomes larger in proportion to Ab . In the three cases in which $\frac{L}{H}$ increases and $\frac{H}{B}$ decreases during growth from one group to the next, one must suppose that an "outgrowth" has taken place, caused probably by the formation of very large projecting ribs, or else that the apex of the shell has been abraded. The latter explanation is probably the true one for the 55-60 mm. shells, for such old shells are usually very much worn and eroded, especially towards the apex.

The change in the ratio $\frac{Ab}{Af}$ may possibly be due also in part to the unequal rates of growth of the anterior and posterior margins. There is some reason to think that the anterior margin grows a little quicker than the posterior. If one examine a well-preserved "smooth" shell (see 9. p. 868) from above, one sees numerous fine ribs radiating from the apex. Now it very often happens that many of the lateral ribs curve slightly forward, while the anterior and posterior ribs run out in a straight line from the central apex. This shows that during growth the mantle (or the whole limpet perhaps) gets shifted forward a little relatively to the apex, and that accordingly the growth of the anterior margin becomes somewhat greater in proportion to that of the posterior margin. The ribs of the shell end in little projections of the rim, and to these projections of the rim correspond little projections of the edge of the mantle, hence from a curving forward of the ribs one can infer a movement forward of the mantle relatively to the shell-apex.

In addition to the radiating ribs there are visible on unworn shells numerous lines of growth. These are often very distinct, especially at about the level corresponding to lengths of 15 mm. and 30 mm. The shell lying between these two levels is probably added during the first summer and autumn's growth. It is, however, hardly possible to recognise annual lines of growth on the shell other than these two.

Shells of 40 mm. and more are usually very much worn on the upper part, from a level of 30 mm. upwards.

Besides the changes in shape during growth there is also a marked change in the build of the shell. It becomes very much thicker and heavier. This increase in thickness (out of proportion to the increase in length) becomes noticeable from a length of about 25-30 mm. onwards, *i. e.* in one year old shells and older ones. The rim becomes considerably thickened, and a great deal of shell-material is laid down inside the apex, which soon becomes solid to quite a considerable depth. In a limpet of 60 mm. the thickness of the shell at the apex was so great as 10 mm.

Throughout all these changes there persists a great uniformity. The relation that $L > B > Ab > Af > H$ had no exceptions in the one thousand and three shells measured, except that occasionally in small shells B equalled Ab . The apex is always nearer to the anterior margin than to the posterior margin. The greatest breadth is invariably behind the apex, and usually behind the middle point of the shell, so that the outline of the margin is not an ellipse. Some results published by Malard (7) are obtained upon the assumption that the outline of the shell-margin may be treated as an ellipse. The index of ellipticity is calculated for several subspecies of *Patella*, and also an index of height. It does not appear that any allowance was made for the differences in the ratio of length to breadth and of each to height, which are found in shells of different lengths. For a form collected at Barfleur the index of ellipticity was '6908; the curve of frequency was asymmetric and of Type I. Malard's inference that in this case selection was more pronounced in one direction than the other is quite unjustified.

The question naturally arises, are these changes in shape simply due to "laws of growth," or are they brought about by selection? It seems fairly certain that the changes in the ratios of the various dimensions of the shell are not due to the action of a process of natural selection, and that for two reasons: first, the changes are perfectly continuous and gradual from stage to stage; second, they are exhibited by every shell without exception. If the changes were due in any marked degree to the action of natural selection, a process of differential destruction must have been active at all stages, and one would expect to find dead shells which did not exhibit in their shape the changes which all good-sized limpets show. But such shells are not to be met with.

It can indeed be proved directly that the changes in shape may take place without the action of natural selection. For instance, 76 shells of 40-45 mm. length were collected at the Cloch, Gourock, and the mean breadth at a length of 40-42.5 mm. was calculated. The value obtained was 35.1448 mm., and the ratio of length to breadth was 1.174. The mean breadth at a length of 15-17.5 mm. was also calculated from measurements of 50 to 60 of these shells, advantage being taken of the lines of growth visible on the shell. (A few shells 38-40 mm. in length, collected at the same time as the 40-45 mm. set, were measured in order to make up the number to 60.) The ratio of length to breadth at this length was 1.26. The ratio of length to breadth in 60 shells 15-17.5 mm. in length collected at the same place and time as the large shells was 1.24. Now within the group composed of the 60 large shells natural selection has not acted, for natural selection acts by elimination, and there has been no elimination within the group. It is true that selection may have been at work before the length of 15-17.5 mm. was reached, and that these shells may represent a selected sample of the population below 15-17.5 mm. It is true also that natural selection may

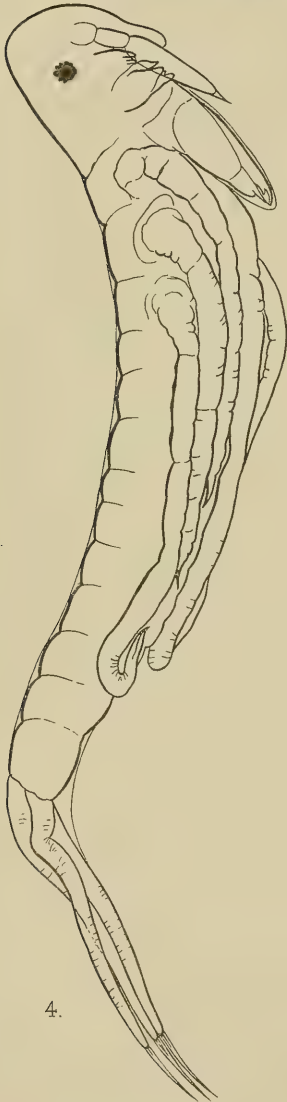
have been at work on other shells 15–42·5 mm. in length—that possibility always remains. But for this group the action of natural selection between the lengths of 15 mm. and 42·5 mm. is excluded. Hence all the changes taking place during this period of growth are independent of selection. Now the values obtained for the ratio of length to breadth approximate very closely to those obtained for Groups 15–20 mm. and 40–45 mm. of the large series (Table VII.), and though the value for the breadth of the 40–42·5 shells at 15–17·5 mm. long (1·26) falls somewhat below the value of the ratio in Group 15–20 mm. (1·27), and might lead one to think that these shells were a selected lot, yet the value of the ratio for the 60 shells 15–17·5 mm. in length is even more divergent, being only 1·24. The differences are clearly due to the difference in environment, the series of which the ratios are tabulated in Table VII. having been collected in the Southend of Arran. One objection may be made to these results, and that is that shells of 40–45 mm. are usually very much abraded towards the apex, and consequently the measurements made on them at a length of 15–17·5 mm. cannot be depended upon. This objection has some weight, and to corroborate my results I have made measurements of 100 “smooth” shells 25–35 mm. in length (75 of them being 25–30 mm. long), which were carefully selected from over two hundred very kindly collected for me by Mr. David Baird, M.A., from the shore where my original set of 1000 had been gathered. The shells selected were those which had suffered practically nothing from weathering, and I am certain that the results they give are not appreciably influenced by the effects of abrasion and erosion. The ratio at a length of 15–17·5 mm. on these shells was 1·22, and at a length of 24–26·5 mm. it was 1·19. The change in this ratio may quite certainly be set down to a “law of growth” and not to selection. This change comes about in approximately four months’ time.

Summary.

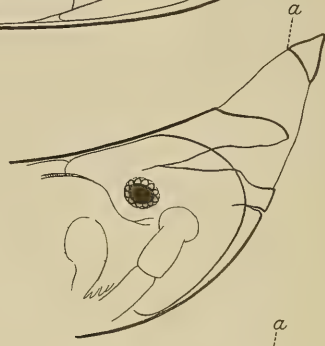
- (1) The breeding-season extends from July to January.
- (2) Sexual maturity is reached at a length of 20–25 mm.
- (3) An average size for a limpet of the last season’s brood in January or February is 10 mm. At the end of the first year it may be 29 mm. long. Probable sizes at the end of the second and subsequent years are 38 mm., 44 mm., 48 mm., 53 mm. Shells over 50 mm. may be considerably more than five years old.
- (4) Sexual maturity is reached in the first year, and when the limpet is only half-grown.
- (5) The rate of growth decreases with age and maturity. It is slower during the colder months of the year.
- (6) Considerable changes take place in the ratios of the shell-dimensions during growth.
- (7) These changes are probably in large part the expression of “laws of growth,” and not due to natural selection.



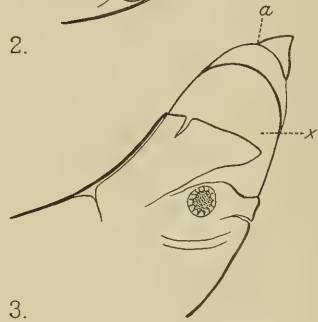
1.



4.



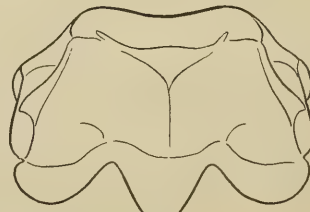
2.



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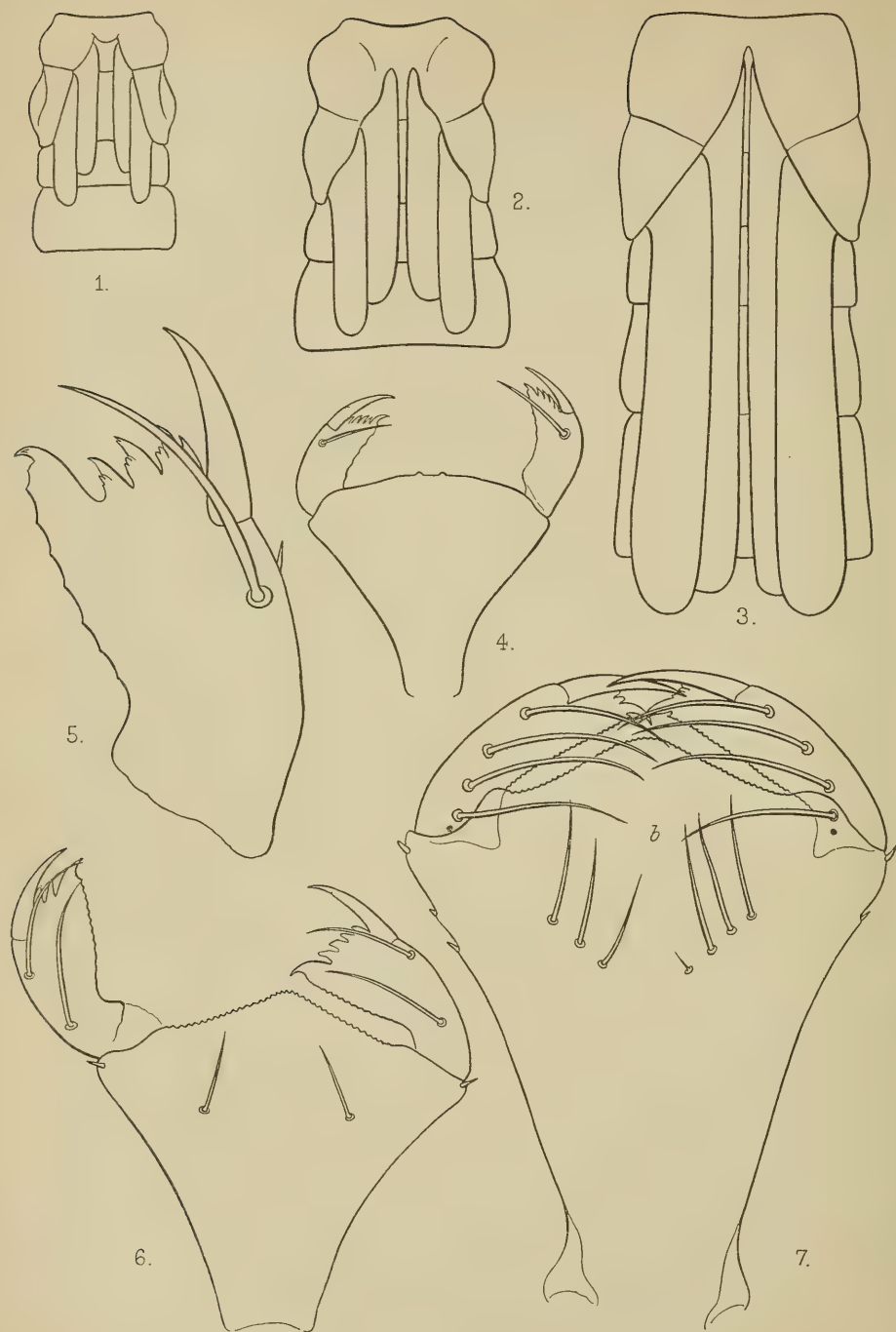


5.



6.

West, Newman lith.



West, Newman lith.

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EXPLANATION OF PLATE XXXII.

SHELLS OF *Patella vulgata* L.

The actual lengths of the shells are as follows.—

1st Row.—7 mm., 8·9 mm., 10 mm., 11 mm., 13·5 mm., 15·4 mm., 17·2 mm.

2nd Row.—20·8 mm., 23 mm. (sexually mature), 26·6 mm. (about 12 months old), 30 mm. (15 months).

3rd Row.—33·3 mm., 38·5 mm. (over 2 years), 40·7 mm.

4th Row.—44·1 mm. (over 3 years), 47·3 mm. (about 4 years), 51·2 mm. (about 5 years).

5th Row.—53·5 mm., 61·2 mm. These two limpets are at least six years old, and may be more.

3. The Life-History of the Agrionid Dragonfly.

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[Received February 5, 1909.]

(Plates XXXIII. & XXXIV.*)

INTRODUCTION.

So far as I have been able to find, the life-history of the Dragonfly has not, up to the present, been studied in detail by anyone. Various facts have been noted by different observers, but no one has apparently attempted to hatch the eggs and follow out the changes which take place during the larval or nymphal condition.

The general facts in the life-history are well known. The perfect insect lays its eggs in the water; after an unknown period there emerges from the egg a sub-aquatic creature known as a nymph, which grows, casting its skin at unknown intervals,

* For explanation of the Plates see p. 285.

and which finally crawls out of the water and dries itself in preparation for the final ecdysis.

In this paper I propose to describe the details of the development so far as I have been able to ascertain them; and, while so doing, I shall incorporate a few casual observations on the anatomy which have been made in the course of the work and from watching the living creatures themselves. Although incomplete, these observations are, I believe, accurate, and may prove of some use to those interested in the comparative anatomy of the Insecta.

I commenced studying the Dragonfly in 1903, at the Sutton Broad Laboratory; but it was not until July 1906 that I seriously undertook the investigation of the life-history. From the literature on the Odonata I was able to obtain but little assistance. Packard (1866) published a paper on the development of the Dragonfly *Diplax*; but that paper deals for the most part with embryology, and the illustration of the newly-hatched larva—which is reproduced by Dr. Sharp, (1895, p. 419),—although truly representing the first stage of the true nymph, does not represent the creature as it comes out of the egg. Brandt, Dufour, Amans, Gilson, and various others who have worked at the Odonata have dealt with their anatomy and physiology, but not with their life-history; and W. J. Lucas (1900), in his book on the British Dragonflies, only refers in a general way to the life-history. He also makes the mistake of regarding the first stage of the true nymph of *Sympetrum striolatum* as the form which emerges from the egg.

It was necessary therefore to start *de novo*, and for this purpose I endeavoured to collect some eggs from the dykes in the neighbourhood of the Laboratory. The females of all the Zygopteridæ, or thin-bodied dragonflies, like those of the *Æschnidæ* but unlike those of other Anisopterids such as Libellulidæ, Gomphidæ, &c., are possessed of an ovipositor and lay their eggs in the tissues of floating aquatic plants. They settle on a floating leaf of *Hydrocharis*, *Potamogeton*, *Anacharis*, &c., and dip the end of the abdomen into the water, often immersing the whole of it. According to some books, the females actually go under water at times when ovipositing; but I have never seen this. In the case of those plants with broad floating leaves, the apex of the abdomen is curved under the leaf so that the ovipositor, which is on the ventral side of the 9th abdominal segment, is brought into contact with the lower surface. The ovipositor consists of two equal lobes placed side by side, each with a sharp point projecting backward. The two halves of the ovipositor work together and pierce a small hole in the leaf-tissue. They then separate slightly from each other, and between them a single elongated egg passes down and becomes wedged in the hole in the leaf. Only one egg is buried in each hole. Some discrimination is exercised as to the piercing of the plant-tissues, as the ovipositor moves about over the surface

before actually entering the leaf. The eggs are easily found in the thin leaves by holding these up to the light.

East Norfolk is rich in dragonflies*, not only in species but in individuals. A great number of females of *Agrion pulchellum* Lind., *Ischnura elegans* (Lind.), *Erythromma najas* (Hansen), *Lestes sponsa* (Hansen), and *Enallagma cyathigerum* (Charp.) were ovipositing at Sutton in the end of July. Eggs were therefore not difficult to find; but it was a somewhat laborious task to collect a large number, and, apart from this, it was impossible to know to which species any egg belonged or how long it had been laid. I therefore constructed a large cage, 15" x 12" x 12", consisting of a wire frame covered with muslin, and this was placed over a large photographic developing-dish half filled with water. On the water I floated a few clean young leaves of the frog-bit (*Hydrocharis morsus-ranæ* L.) cut off from the plant, having first examined them carefully to make sure they contained no dragonfly eggs. I then captured six pairs of *Agrion pulchellum* Lind. and put them in the cage. It is extraordinary how dependent upon the direct sunlight is the vitality of these insects. On dull days, or when the cage was in the shade, the prisoners were in what appeared to be a torpid condition, clinging to the muslin sides of the cage and not moving for hours at a time; but on a bright day, or as soon as the cage was put into the sunlight, the scene became one of extraordinary activity: the males fighting one another for the females, and the combatants constantly falling into the water, from which, however, they always succeeded in escaping.

The peculiarity of the male reproductive organs—the vasa deferentia opening on the sternite of the 9th abdominal segment, while the organ of intromission is situated on that of the 2nd segment,—and the consequent peculiar method of transference of the spermatozoa to the female are apparently unique in the Odonata. I have never seen the actual transfer of the sperm to the sperm-sacs of the male, although in some individuals which have emerged in captivity I have noticed the tendency to curl the abdomen as if making attempts to bring the 9th and 2nd abdominal sternites into contact. Whether the sperm is transferred to the sacs once and for all, or whether the supply in the sacs is replenished from time to time, has apparently not been observed; but the female, at intervals in the process of oviposition, obtains further supplies of sperm from the male.

The male is furnished with claspers at the apex of the abdomen, by which he grips the notum of the prothorax of the female; and the pair fly about attached in this manner. The adaptation of these parts to one another is so close that only the claspers of the male of its own species can hold the prothorax of a female. Thus one very definite means of separating the females of *A. pulchellum*

* See 'Victoria County History: Norfolk,' vol. i. (1901). Also, for Agrionidae, "A Bionomical Investigation of the Norfolk Broad," Trans. Norfolk & Norwich Nat. Soc. vol. vii. (1904).

and *A. puella*, which very closely resemble each other, is the form of the notum of the prothorax, and I give drawings of this part of both these species. It will be seen that the males also differ somewhat in this respect, but to a less extent than the females.

Either while a pair are flying about attached *per collem*, or while so resting, the female curves her abdomen underneath her in such a way as to bring the underside of her 9th segment into contact with that of the 2nd abdominal segment of the male; and the parts are so constructed that a firm attachment can take place, and the spermatozoa are transferred from the sperm-sacs of the male to the oviducts of the female.

After a contact of shorter or longer duration, from a few seconds to a minute or more, the female once more straightens herself out and sooner or later oviposition commences. This is most commonly done while the male is still holding the female *per collem*, but, though I believe less commonly, the female will oviposit without being held by the male. The male remains entirely passive during oviposition, apparently obeying the will of the female. When she flies, he also flies; but she directs, or seems to direct, the course. She seeks the aquatic vegetation and deposits her eggs as already explained. The male meanwhile rests either with his legs on the leaf or more commonly standing erect in the air, his body rigid, his legs folded, and himself supported only by the claspers attached to the prothorax of the female.

I kept the prisoners in the cage for about a week, feeding them on flies and other insects captured with the sweeping-net. The prey crawled about on the muslin, and the dragonflies, flying about in the cage, picked them off and either ate them while still flying or after settling on the sides. A large number of eggs were meanwhile deposited in the frog-bit leaves, besides very many which I found in the bottom of the dish. The eggs were laid during the first four days of August, and I placed the frog-bit leaves in tumblers of clean water and also collected a number of the loose eggs and dealt similarly with them.

After about a fortnight the leaves showed signs of decay; and towards the end of August nothing of them remained but a mass of decayed vegetation at the bottom of each of the tumblers, and my hopes of seeing any nymphs from the eggs vanished. However, on the 28th of the month numbers of nymphs appeared on the top of the mass of decay—almost four weeks after the deposition of the eggs. Although the majority of the eggs hatched at one time, nymphs were appearing for a fortnight or three weeks after that; and the same fact was noticed with the eggs of *Ischnura elegans* on another occasion.

The eggs which were dropped in the bottom of the dish never developed at all, and were all decomposing within 10 days. I have found that the eggs of the water-beetle *Dytiscus* also failed to hatch when cast loose instead of being buried in plant-tissues, as they normally are; and Miall (1895, p. 40) mentions that Lyonnet also found that loose eggs of *Dytiscus* never hatched.

It has occurred to me that this failure of loose eggs is due to asphyxiation, as possibly the eggs buried in the plant-tissues obtain a certain amount of air from the intercellular spaces of the plant; but if this is the case, it is somewhat surprising that the decaying leaves of the frog-bit retained sufficient air to supply a fair number of eggs.

At the time when the nymphs appeared I did not observe the emergence of the nymph from the egg; but I have since had the opportunity of watching nymphs of *Ischnura elegans* hatch, and I have no doubt, from the similarity in all the later stages, that the peculiar phenomena observed in the case of *I. elegans* occur in all the Agrionidæ, and, from the fact that I have observed some of the same phenomena in one of the Anisopterids, *Sympetrum striolatum*, they are evidently common to all the Odonata.

The dragonfly, both as a nymph and as an imago, requires living animals as food, and at the commencement of the work the difficulty was to find food small enough for the nymphs, which were but little over 1 mm. in body length. An infusion of horse-dung in water solved this difficulty, as in a few days it swarmed with life, one jar in particular constantly producing, for five or six months, a rich supply of *Paramæcia*, which the nymphs ate readily. As the nymphs grew the *Paramæcia* were replaced by daphnids, and it was surprising what large specimens the nymphs caught and demolished. Daphnids served as food all through the nymph stage after the protozoa became insufficient.

The nymphs proved exceedingly easy to rear. A number of them, as soon as they appeared, were sorted out and measured, and each was then placed in a tumbler of water by itself, a small piece of *Anacharis* being put in to give it foothold and also to keep the water fresh. Each tumbler was then labelled, and a record kept of the life of its occupant. The water in the tumblers was only very occasionally changed, and only when the glass became so thickly coated with algae that I could not see the inmate. For the first two months of their life the nymphs were examined and measured under the microscope at least twice a week—for the first week or two, every other day; but such frequent interference with their existence proved unnecessary, and latterly the examination and measurement was much less frequent, being almost entirely confined to the times of moulting.

Although I have only followed *Agrion pulchellum* and *Ischnura elegans* right through from the egg to the imago, I have also kept through many stages nymphs of *Pyrrhosoma nymphula* and *Erythromma najas*, and from my observations I think there is no doubt that, so far as the general facts go, what is true for one of these species is true for all the others.

In this paper I am treating the subject from two points of view. First, I have detailed the phenomena observed in relation to the stages in the life-history in which they occurred, the stages

being marked by the successive moults. I have then gone into some detail with regard to the development of the form of the nymph—that is, morphologically rather than anatomically; and in this part of the subject one or two interesting facts as to the manner of growth of the external parts have been observed. This detail has brought to light a certain want of agreement between the stages as marked by the moults and the stages in the development of these external parts; and I have therefore, in conclusion, reviewed the question from the point of view of the significance of the moult. This latter part of the paper is very incomplete, since, although a number of facts on the subject of the moult in insects are known, there is insufficient material at present upon which to base any really satisfactory theory. However, this is merely forestalling the conclusion.

THE PRONYMPH.

The Agrionid egg is an elongated body, rounded at one end and bluntly pointed at the other, the point being a small pedicel. In *Agrion pulchellum* and *Ischnura elegans* its length is about 1.3 mm., but the size no doubt varies in the different species. The egg is inserted, as already explained, in the soft tissues of aquatic plants, the pedicel end being the last to leave the oviduct and being therefore nearer to the surface of the leaf in which the egg is deposited.

The period of incubation varies somewhat in length according to temperature, apart from the fact that all the eggs of a batch do not hatch on the same day. Eggs laid in the beginning of August took just less than four weeks before the bulk of them hatched, while eggs laid later in the year did not hatch for more than five weeks.

For some time previous to hatching the position of the nymph within the shell is easily made out. The head lies at the pedicel end of the egg, the antennæ, first maxillæ, and labium being directed backward on the ventral side of it. The first and second pairs of legs lie straight out along the ventral side of the abdomen, while the third pair are bent on themselves at about the junction of the tibiæ and tarsi, the latter lying forward below the tibiæ. The posterior abdominal segments curve round in the shell ventrally, the 10th occupying the rounded end of the shell. The caudal lamellæ lie forward along the ventral side, between the legs and the shell.

For at least three days before the egg is ready to hatch the heart can be seen beating, at first slowly but getting faster as the time approaches for the emergence of the pronymph. The posterior end of the heart is the part which develops and pulsates first, and although in the free nymph this is in the 9th abdominal segment, in the egg it appears to lie in the 10th segment.

The first sign of the approaching emergence of the pronymph is the cracking of the shell immediately beneath the pedicel. At

this time the heart is beating vigorously, at about 100 pulsations per minute. The pedicel is then seen to be slightly removed from the egg, owing to the bulging out from the egg of an extremely fine membrane which is evidently extended with fluid. This membrane continues to expand until there is a gap of about .15 mm. or even more between the pedicel and the rest of the shell. It is noticeable also that the pedicel is not carried up in a line with the axis of the egg, but rather dorsally to the axis, and although this process was only watched in two or three cases I believe that the direction of expansion of the membrane is perfectly definite.

This carrying up of the pedicel and the formation of the vesicle occupies one or more hours, and except for some occasional slight writhing movements of the gut and of the abdominal segments within the shell no other change is noticeable during that time. The vesicle is, in fact, formed many hours before the pronymph begins to emerge. Some time after the formation of the vesicle a pulsating organ appears in the head in the region of the mouth; and one or two hours after this organ begins to pulsate, the head of the pronymph begins to expand into the vesicle. It takes the shape of the passage, losing all semblance of a head, and slowly fills the vesicle until it once more touches the pedicel. All this time the pulsating organ continues to beat at about 28 beats per minute.

As the head begins to enter the vesicle the walls of the latter bulge slightly, showing that they are extended by fluid which is being compressed by the head. Almost as soon as the head completely occupies the vesicle the membrane bursts along the dorsal edge of the pedicel and the enclosed pronymph slowly comes out. Just previous to this body-movements are more noticeable, and the tenth abdominal segment moves round so as to be in line with the others; but until the membrane bursts, no part of the shell is unoccupied.

The pronymph appears to flow out of the shell at the start, but almost immediately it exerts itself and wriggles from side to side. It comes out in exactly the position in which it has lain in the shell; the lamellæ, bent under the body, coming out points first. The lamellæ straighten out more or less once the larva is clear of the shell, but the legs and mouth-parts remain outstretched and directed backwards.

From the moment of its escape the pronymph—a helpless cripple—shows active writhing movements, and within two or three minutes the skin on the back of the thorax splits along the median line and a moult takes place. The posterior abdominal segments contract and expand and gradually creep up inside the pronymph skin, drawing the lamellæ out of their sheaths. As the abdominal segments press forward, the thorax becomes arched up and the head bent down. The pressure in the dorsal region of the thorax ruptures the skin along the median line, and the thorax rises up through the split. In doing so it ruptures the skin further

forward, and the head with the antennæ and mouth-parts is drawn backward and upward out of the old skin and all these parts at once assume their normal position—the antennæ pointing forwards, the labium doubling on itself and taking up its position below the mouth, the maxillæ likewise bending forwards and coming to lie on either side of the mouth immediately below the jaws. Further writhing of the abdominal segments forces the body still further out of the skin, and the legs are withdrawn from their sheaths. Once the legs are free, a final struggle clears the nymph of the pronymph skin. This latter is exceedingly thin and transparent, and almost invisible even under the microscope except for the fact that on each side of it is an irregular band of backwardly-turned projecting points. These lie scattered on either side of the thoracic and abdominal segments, but there is none on the head. These points are no doubt of use in assisting the pronymph to escape from the egg.

Owing to scarcity of material after the discovery of the above details of the pronymph stage, I was able to observe the emergence from the egg only in two or three cases, and I had not therefore opportunity of making many observations on the pulsating organ already referred to. Several points were, however, noted. The organ is not far from the position of the mouth; it contracts from in front backwards, apparently driving blood, since the corpuscles were visible, posteriorly, and the pulsation and direction of the flow were quite distinct. The drive was towards the dorsal surface near the posterior margin of the head, and a blood-vessel in that region (the aorta?) could be seen showing slight bulging each time the liquid was forced to it. Blood could also be seen passing from the anterior part of the head back to the pulsating organ; but at times this flow ceased and the corpuscles appeared to oscillate backwards and forwards at each beat of the organ, just as they may often be seen to do in the ordinary blood-spaces of the body.

I could find no trace of a pulsating organ in the pronymph after it had escaped from the egg; but this might have been due to the fact that the creature was in constant movement for the two or three minutes of its existence. There is apparently no such organ in the nymph. If it only appears, as I believe, after the formation of the vesicle and disappears or ceases to pulsate as soon as the pronymph escapes from the egg, the obvious inference is that it has something to do with the emergence of the pronymph, and is, in fact, an embryonic organ. It is interesting in this connection that Wheeler (1893) has described an embryonic "subœsophageal organ" as occurring in insects, of which he says the cells somewhat resemble those of the fat-body. He places it in the tritocerebral segment of the head, and says that it disintegrates in the larva.

The function of the pulsating organ in the head of the *Agrionid* embryo seems to be to absorb the fluid in the vesicle, so as to allow the head to pass into it; but how it can do so is at present

a mystery. In the embryo of the water-beetle (*Hydrobius fuscipes* L.) I find that there is a cephalic pulsating organ which becomes active a few hours before the escape of the embryo from the egg, and that during its activity the embryo enlarges so as to completely fill the egg. There is, however, no vesicle formed, and in that case I am almost certain the pulsating organ is not a special structure but merely a pharyngeal pump, which is found in the larva after its emergence and is similar to that in all suctorial insects. In the Agrionid nymph, however, there is no suctorial apparatus; apart from which, the blood-corpuscles visible in the pulsating organ oppose the idea that it is part of the alimentary canal.

Circulatory pumps, accessory to the heart, have already been described in insects, but so far, I believe, they have only been observed in imagines and larvæ and not as embryonic organs. Behn (1835) first discovered them in the legs of various Hemiptera, and Selvatico (1887), Pawlowa (1895), and others have described them in the heads of certain Lepidoptera and Orthoptera. Selvatico describes an enlargement at the anterior end of the aorta—the “frontal sac,” a description which might possibly suit the organ in the Agrionid embryo.

The reversal of the blood-stream observed in the embryo is also not unique*, as Bataillon (1893) observed the same phenomenon in the pupa of the silkworm.

With regard to the formation of the vesicle, it is possible that it is due to the displacement of the fluid which presumably surrounds the embryo within the shell, or possibly the fluid is extruded from the embryo to be later reabsorbed.

Much, however, remains to be discovered with regard to these phenomena in the egg.

THE NYMPH. *Stage 1.*

The nymph which escapes from the pronymph skin is no longer than the pronymph, in fact the total length—not including the caudal lamellæ—is just about that of the egg from which it came. It consists of a head, 3 thoracic and 10 abdominal segments, and is an excellent example of the campodeiform larva. The head bears two antennæ, each of which consists of 3 segments, two basal ones, which are of characteristic form and except in size do not show any change during the life of the nymph, and a long bluntly pointed, slightly incurved apical one. Not far from its apex, and on its outer side, this apical segment bears a very small spur. The length of this segment is equal to about 70 per cent. of the whole antenna.

The mouth-parts consist of a pair of jaws of the usual

* I have recently observed a reversal of the blood-stream in the heart of a well-grown nymph, and I imagine the blood was also passing into the last chamber of the heart by the last pair of ostæa. It was escaping by the ostæa in the 8th abdominal segment.

"mandibulate" type, a pair of maxillæ, and a labium of very special form usually known as "the mask." It is in shape more or less an isosceles triangle, the apex being turned posteriorly and lying, when in a state of rest, underneath the first thoracic segment. The base of the triangle is presented forwards and at each of the anterior corners is attached an appendage representing a labial palpus, which again is rather triangular in shape, being flattened above and below and having three sides, one of which is anterior. At its outer anterior extremity each palp bears a movable claw, and along its anterior border each palp is beset with four or five teeth, the innermost being much the largest and slightly curved inwards. The inner border of each palp is serrated, the teeth being small and curved slightly backward. The anterior border of the labium itself is also slightly serrated*, and when the mask is not in use the palpi lie against this border in such a way that the anterior edges of the two interlock, the movable claws overlapping. On the upper side of each palpus, attached near its outer border and not far behind the movable claw, is a single long incurved hair or bristle.

The thoracic segments bear each a pair of legs, but at this stage there is no trace of the wings nor are the pleural ridges present. Except for the possession of the legs there is nothing in outward appearance to distinguish the thoracic from the abdominal segments. These latter are also very similar to one another, except that the body tapers slightly towards the posterior end. The tenth segment bears the three caudal lamellæ, one median situated above the anus and two laterals, one on either side of the anus. The two main tracheæ, which pass along each side of the thorax and abdomen, curve inward and upward in the tenth segment and run out side by side in the middle lamella. At the points where they curve upward a single branch continues as a fine tube into the lateral lamella of its own side. The lamellæ at this stage are tubular, perhaps slightly triangular in transverse section, tapering to their apices and ending in a fine long hair; they bear along two or three lines a series of small hairs and in *Agrion pulchellum* they contain two patches of pigment, one near the apex and one about halfway from the base.

The transparency of the nymph at this stage enables one to see fairly well the internal organs. The gut consists of a pharynx leading to an œsophagus which opens out into a large thin-walled sac—which is apparently contractile—occupying the thoracic segments. At the posterior end of this sac there is a constriction, and immediately behind this is another large thin-walled sac which occupies most of the first six abdominal segments. This sac—the mid gut—is constricted posteriorly and opens into a small globular contractile portion of the intestine, in the anterior end of which open two Malpighian tubules, one on either side and

* The serration does not appear on either the palpi or the labium until a later stage. Only faint traces of it are visible at this stage.

slightly dorsally. The rectum is the continuation of the small intestine and occupies almost the whole of the last four segments of the body. The small intestine at one time appears globular and at another as a thick cord of tissue, the contractions apparently commencing anteriorly and passing backwards. A contraction begun in the small intestine continues through the rectum, which, like the former, is sometimes a large sac and sometimes a thick cord. With regard to the number of Malpighian tubules, Wheeler (1891-3) suggests that the embryonic number in the Odonata "will probably be found to be 4 or 6." There are, however, only two in *Agrion pulchellum* at this stage.

The heart consists of nine compartments and lies in the abdominal segments 1 to 9. Each compartment is separated from the next by a pair of very distinct valves, which lie in the posterior region of each abdominal segment. Immediately in front of each pair of valves is a pair of ostia in the lateral walls of the heart, so arranged that when the valves are open between two compartments the ostia are closed. The heart opens anteriorly into the dorsal vessel, or aorta, which has only a slight contractile power, and this vessel runs forward into the anterior region of the head, where the blood-stream divides into two and passes downwards in front of the head.

There is at this stage no circulation in the antennæ or in the limbs. The blood returns through the body by various lacunæ. The two large lateral sinuses, in which at later stages the blood-flow is easily seen, are but little developed at present. The corpuscles, which are large more or less oat-shaped bodies, can be seen passing backwards along the "pericardium," and a few can be seen every now and again making their way up from the lateral sinuses and after much oscillation entering the heart by some of the anterior ostia. The great majority of the corpuscles, however, re-enter the heart by the two large ostia situated at the posterior end of the 9th segment. Between these two ostia is a strong ligament passing back into the 10th segment.

The ventral nervous system, so far as it is visible in the living nymph, consists of a large (double) ganglion in each of the abdominal segments 1 to 7, and between the ganglia the cord is double, the two parts being quite separate. Behind segment 7 these two cords pass backwards and break up into finer nerves.

There is no sign at this stage of any sexual armature. This first appears, I believe, about the 7th stage, but I have made very few observations on this point.

Stage 2.

At the first moult of the true nymph certain changes are visible, showing an advance in organization. The antennæ are now composed of 4 segments, the apical one having divided transversely into two of almost equal length. The labial palpi now each bear two long stiff incurved hairs, the second hair having

appeared below the first at the same distance from the external edge of the palp and much nearer the base.

The lamellæ show no change in shape, but the two lateral ones now possess two tracheal tubes, the main branch as it enters the base having given off a smaller branch which runs up the lamellæ parallel with the main one.

In some specimens at this stage circulation of the blood is visible in the basal segments of the third pair of legs, but, as a rule, there appeared to be no difference in this respect between this stage and the previous one.

Stage 3.

The antennæ now consist of 5 segments, the third from the base having divided, cutting off about one-third of its length at the distal end to produce the new segment.

No change takes place in the labial palpi, but one pair of long stiff hairs has appeared on the upper surface of the labium itself. These hairs are situated nearer the anterior than the posterior end and are on each side of the median line fairly wide apart. They are directed forwards and, when the labium is at rest below the head, are immediately behind the mouth of the nymph.

The lamellæ are slightly wider vertically than before, but it will be necessary to deal with their development separately, as their changes apparently correspond with the rate of growth of the nymph rather than with the stage in its life-history.

At this stage there seems to be usually, if not always, circulation of the blood in the bases of the legs, but there is still none in the antennæ or in the lamellæ. I am not certain as to when circulation begins in these latter organs, but it appears to be established about the 6th or 7th stage, if not earlier. One interesting point concerning it is that it is apparently intermittent, as there are times when it is impossible to see any corpuscles moving, while at other times the flow is distinct and rapid. The circulation in these organs seems to be confined to the region round the main tracheal trunks, there being in each lamella a blood-space above and below these tracheæ. The direction of the flow in these blood-spaces seems to be reversible, as at times the blood may be seen flowing outwards above the trachea and inwards below, while at other times the opposite is the case. The circulation in the middle lamella also is sometimes the opposite of what it is in the lateral ones. At times the corpuscles oscillate backwards and forwards on both sides of the tracheal trunks. I shall have more to say concerning the lamellæ when I come to discuss the moults.

In one individual examined at this stage there were three Malpighian tubules.

Stage 4.

At the third moult no increase takes place in the number of

segments of the antennæ. In the labium the labial palpi now each bear 3 hairs, the new ones having been added below the second. A second pair of hairs has also appeared on the body of the labium between the other two hairs. These new hairs may be as large as the first pair or they may be smaller, only attaining full size at the next moult. In later stages the new hairs always appear as minute spines and are often only half their full size after the following moult, although they are more usually full size by that time.

A marked increase in the extent of the circulation is now visible. The corpuscles can be seen passing up the inner side of the first, second, and part of the third antennal segments. About halfway up the latter segment they cross over to the outside of the antenna and return to the head. Circulation is also distinctly visible in the bases of the legs as far as the trochanters, passing out from the body anteriorly and back to the body along the posterior side and beneath the tracheal tube.

In the femora an irregular movement of blood-corpuscles is recognizable, but very few seem to be present and these are constantly being temporarily held up among the muscle-fibres.

Usually, in this stage, small ridges appear on either side of the second and third thoracic segments, this being the first trace of wing-development. The appearance of these ridges is not, however, always in stage 4. In a few instances I have noticed them in the previous stage, while in many cases they do not appear until the fifth stage, but either stage 4 or 5 seems to be the normal one for their appearance. The development of the wings, like that of the lamellæ, seems more closely connected with body-growth than with the moults. This statement, however, requires some qualification, for, although it is not possible to describe any definite condition of wing-development as being connected with any particular moult, there seem to be one or two very definite stages correlated with the approach of the final ecdysis. This will, however, be referred to later.

Stage 5.

A further increase in the number of antennal segments takes place at the fourth moult, the third segment from the base again dividing into two equal parts. This 6-segmented condition of the antennæ continues through the next four stages, in fact, until the commencement of the final nymphal stage is reached, when a change takes place.

The condition of the labium remains the same as in the previous stage.

Although no regular record has been kept of the rate of increase in the number of Malpighian tubercles, one nymph examined in the fifth stage had either 5 or 6 of these. The rate of increase in the number of these must become more rapid later

on, as Schindler (1878) describes 50 or 60 as being present in the imago of *Agrion puella*.

Stages 6, 7, 8, and 9.

The labium in stage 6 usually has 4 hairs on each palp and three pairs on the labium. Each new pair of hairs as it appears on the labium arises between the original hairs, so that gradually the series takes the form of a crescent with the ends curving forwards stretched across the labium. In stage 7 the condition of the labium is usually the same as in stage 6.

In stage 8 the labium may be just as in the previous stage, but often, perhaps more usually, either a pair of new hairs has appeared in the crescent or one hair only has appeared, so that there are 4 hairs on one side and 3 on the other. I noticed this irregularity in a number of cases, and although such uneven developments occur in other stages they do not seem to be so common as in this one. Occasionally there are 5 hairs on each of the palpi. In stage 9 there seem to be, with scarcely any exception, 5 hairs on each palp and 4 pairs on the labium.

Stage 10.

This may be the final stage in the life of the nymph. The antennæ, if this is the final stage, will be seen to possess 7 segments, the additional one having been produced by the division of the 6th immediately above the small spur already referred to. I am not certain that this division takes place in all the *Agrionidae*, but the statement holds good for *Agrion pulchellum* and *puella*, *Pyrrosoma nymphula*, and *Ischnura elegans*. I think that the nymph of *Erythromma najas* has antennæ of only 6 segments in its final stage, but I can only find notes as to one specimen of this species. Similarly, with regard to *Enallagma cyathigerum*, the only specimen of which I have kept a record had 6-segmented antennæ in its final stage. When this is the final stage of the nymph, the labial palpi usually possess 6 hairs each, while the body of the labium has a crescent of 10 hairs more or less evenly spaced and all pointing forwards. In other cases, however, the labium may remain as in stage 9 or there may be an intermediate condition, 5 hairs on each palp and 5 pairs on the labium itself.

The blood-circulation in nymphs in the later stages is, in the legs, apparently the same as described for stage 4. Bowerbank (1833, p. 243) describes the blood as circulating in the leg of *Agrion* "even to the very extremity of the tarsus, where, as in the antennæ, the particles of the blood are seen to descend on the one side of the leg and turning the extreme point to return up the contrary side to the one by which they came down." Even in the full-grown nymph I cannot detect a regular circulation beyond the trochanters, where the corpuscles can be distinctly seen passing from the anterior to the posterior side and returning

to the body. This circulation is rapid—as rapid as in the abdominal segments,—but that in the tibiae and tarsi is extremely slow and irregular, the few visible corpuscles being constantly held up for quite long periods.

In the antennæ the circulation extends now to the apex of the 5th segment. A few corpuscles can be seen travelling up the inner side very irregularly, there being constant delays and short rushes. At the apex of the 5th segment they quickly pass over to the outer side and travel back to the head in the same easy stages.

Bowerbank (*l. c.*) mentions that the nymph he examined had antennæ of 6 segments and that the circulation only extended to the extremity of the 4th segment—a condition probably reached about the 6th or 7th stage, but I have not paid sufficient attention to the circulation to be more precise.

Stages 11, 12, &c.

If the nymph is not going to hatch out at the end of the 10th stage, the antennæ do not change from the 6-segmented condition. It seems to be a rule in *Agrion* and *Ischnura* that the 7-segmented condition only exists in the final stage, while in *Pyrrosoma* the only two individuals which I reared through the last stages showed the 7-segmented condition in the penultimate stage.

The labium may have either 6 or 7 hairs on each palp and 5 or 6 pairs on the body, while occasionally no further development takes place after the 10th moult. If there are 7 hairs on each palp they are very crowded and the 7th appears at the extreme base of the palp.

The majority of my nymphs hatched out into imagines at the end of the 10th, 11th, or 12th moults. Two *Agrions* passed through 13 stages, while the two *Pyrrosomas* passed through 11 and 12 respectively. A single *Enallagma* passed through 14 stages as did *Erythromma*, while an *Ischnura* imago emerged at the 12th moult. I shall later on discuss the question of the variation in the number of moults in nymphs of the same species.

THE MOULTS.

In the case of the *Agrion* nymphs which hatched from the eggs at the end of August, the first moult took place in from 8 to 12 days. Their average length, after hatching, was 1.3 mm., while after the first moult it was 1.6 mm. The second moult was a less regular event than the first, some nymphs undergoing it 14 days later, while others took more than three weeks to complete their second stage. The third moult again took place from a fortnight to five weeks after the second, while the fourth was even more irregular than the third.

At the beginning of November the nymphs become very

sluggish, showing but little interest in the *Paramœcia* with which they were abundantly supplied.

In the beginning of December, seeing that matters were at a standstill, I placed 18 of the tumblers in a Hearson incubator and maintained a fairly constant temperature of 19° C. (66·2° F.), which is a very high summer temperature. The outer door of the incubator was removed, so as to admit light, but, from the position in which the incubator stood, the occupants had little more than twilight even on the brightest days.

The effect of the warmth was soon obvious, as all the nymphs in the incubator showed great activity and readiness to feed. One nymph moulted 8 days after being placed in the incubator, and others followed fairly soon. By the end of February several of the nymphs had completed their 8th stage, while one was through its 9th and another through its 10th. During the same time the nymphs, some fifty and more, in the ordinary temperature of the laboratory did not moult at all, with the exception of three specimens, two of which moulted at the beginning of December and the other at the end of February. The average length of the nymphs in the incubator was 11·0 mm., while that of those outside was 2·7 mm.!

A large part of the experiment had now to be sacrificed, as I was leaving Norfolk for Ireland, so the incubator was gradually cooled off and the former occupants became less active and much less hungry. On April 20th I started a similar incubator in Larne, and this was kept going until July 10th, but only one or two of the nymphs which had been kept warm during the winter were placed in it, a number of the less advanced ones being selected in order to further test the effects of temperature. The new batch of nymphs quickly showed great activity and keen appetites and began to grow rapidly, moulting at short intervals. If further evidence were needed of the effect of temperature in the causing of moults, it is to be found in the cases of three nymphs, one in the 5th and two in the 6th stage, which had stagnated for 92, 135, and 104 days respectively through the winter. They were placed in the incubator for 21 days in February. Each moulted 7 days after being warmed, and each moulted a second time in the next 10 days. After being removed from the incubator one moulted three weeks later, while the other two were five weeks without changing.

This effect of temperature upon the duration of the stages makes it impossible to find a fair average duration for any stage except by using only those nymphs which have been incubated, and only those stages passed through while in the incubator. Unfortunately, this was not foreseen, so that the material at hand is very meagre. I have, however, prepared a table showing for 19 nymphs the number of days occupied by each stage, indicating the days passed in the incubator by using a thicker type (*v.* Table 1).

From Table 1, reading down the columns and only using the figures for stages begun and completed in the incubator, we can

TABLE I.—Showing the number of days occupied by each stage of the nymph.
The figures in thick type indicate that those days were spent in the incubator.

STAGE	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	Total number of days.
<i>A. pulchellum</i> . Nymph. Sex. 1. ♀ 12 17 14 25 150 16+15 22 5 21 18+12 86* 211 .. 624 2. ♀ 8 11 18 46+10 9 20 8 14 20+71 11 69 296 3. ♀ 12 20 21 57+12 9 9 10 16 25+58 10+48 277 4. ♀ 12 17 14 166+2 9 9 12 14 23 14 229 5. ♀ 12 21 32 166+2 9 9 31 14 23 2+35 234 50 634 6. ♀ 7 17 14 25 92+7 9 9 8 17 24 22 25+29 37 .. 339 7. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 8. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 9. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 10. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 11. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 12. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 13. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 14. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 15. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 16. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 17. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 18. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 19. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291	17	11	14	25	150	16+15	22	5	21	18+12	86*	211	..	624	
<i>L. elegans</i> . Nymph. Sex. 1. ♀ 12 17 14 25 150 16+15 22 5 21 18+12 86* 211 .. 624 2. ♀ 8 11 18 46+10 9 20 8 14 20+71 11 69 296 3. ♀ 12 20 21 57+12 9 9 10 16 25+58 10+48 277 4. ♀ 12 17 14 166+2 9 9 12 14 23 14 229 5. ♀ 12 21 32 166+2 9 9 31 14 23 2+35 234 50 634 6. ♀ 7 17 14 25 92+7 9 9 8 17 24 22 25+29 37 .. 339 7. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 8. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 9. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 10. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 11. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 12. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 13. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 14. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 15. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 16. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 17. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 18. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 19. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291	17	11	14	25	150	16+15	22	5	21	18+12	86*	211	..	624	
<i>E. aeneus</i> . Nymph. Sex. 1. ♀ 12 17 14 25 150 16+15 22 5 21 18+12 86* 211 .. 624 2. ♀ 8 11 18 46+10 9 20 8 14 20+71 11 69 296 3. ♀ 12 20 21 57+12 9 9 10 16 25+58 10+48 277 4. ♀ 12 17 14 166+2 9 9 12 14 23 14 229 5. ♀ 12 21 32 166+2 9 9 31 14 23 2+35 234 50 634 6. ♀ 7 17 14 25 92+7 9 9 8 17 24 22 25+29 37 .. 339 7. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 8. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 9. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 10. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 11. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 12. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 13. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 14. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 15. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 16. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 17. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 18. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 19. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291	17	11	14	25	150	16+15	22	5	21	18+12	86*	211	..	624	
<i>P. agrippina</i> . Nymph. Sex. 1. ♀ 12 17 14 25 150 16+15 22 5 21 18+12 86* 211 .. 624 2. ♀ 8 11 18 46+10 9 20 8 14 20+71 11 69 296 3. ♀ 12 20 21 57+12 9 9 10 16 25+58 10+48 277 4. ♀ 12 17 14 166+2 9 9 12 14 23 14 229 5. ♀ 12 21 32 166+2 9 9 31 14 23 2+35 234 50 634 6. ♀ 7 17 14 25 92+7 9 9 8 17 24 22 25+29 37 .. 339 7. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 8. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 9. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 10. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 11. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 12. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 13. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 14. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 15. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 16. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 17. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 18. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291 19. ♀ 11 24 55 2+15 4 10 14 14 9 4+8 22 26 37 .. 291	17	11	14	25	150	16+15	22	5	21	18+12	86*	211	..	624	

* A month was by mistake not recorded; in No. 2 it occurred in the incubator.

† Only in incubator from April 20th onwards; not during the winter.

‡ Only in incubator during the winter months—December to February.

§ Incubated for 21 days in February, otherwise no winter warmth.

find the average number of days occupied by each stage, and the results, so far as it is possible to get any, are as follows:—

TABLE 2.

Stage.	Average number of days.	Number of nymphs.	Max. number of days.	Min. number of days.
V.	9.5	6	17	4
VI.	15	8	31	9
VII.	12.0	14	22	6
VIII.	13.3	13	23	5
IX.	14.1	12	21	8
X.	19.2	10	47+	9
XI.	29.4+	5	52+	10

The figures indicate that the stages tend to lengthen from the earlier to the later ones. There is, however, a source of error in the method used, and that is that while some nymphs are full-grown at the end of the tenth stage, others go through 11, 12, 13, or 14 stages. Now one point which is quite clear without any statistics is that the final stage is always a fairly long one, and this fact will of course affect the above figures. I have therefore checked these results by using Table 1 in another way. I have taken the average duration of the last stage of each nymph, then of the penultimate stage, then of the one before that, and so on as far back as my figures will permit, again of course only including stages begun and completed in the incubator, and the results are as follows:—

TABLE 3.

Successive stages }	4—8	5—9	6—10	7—11	8—12	Penultimate Stage. 9—13	Last Stage. 10—14
Number of nymphs }	4	11	14	15	11	6	3
Average no. of days }	12.3	10.7	13.4	14.7	16.8	19.5	45.6+
Max. & min. no. of days }	17. 10.	22. 8.	31. 5.	44. 6.	24. 9.	24. 14.	52+ 36.

Again the figures show that the stages tend to lengthen out as the nymph grows bigger.

The first imago to appear emerged 33 weeks (230 days) after hatching from the egg and after passing through 10 stages. This was one of the individuals which spent the winter in the incubator, and I expected to find that all the nymphs which had been kept warm during winter and had fed and moulted regularly would complete their life in the same number of stages. However, out of ten such nymphs only three got through in 10 stages, one in 11, five in 12, and one in 14. The three nymphs which completed in 10 stages were placed in the incubator in their 4th stage, as was

also one which passed through 12 stages, while all the other nymphs were in their 6th, 7th, or 8th stages at the beginning of December. Now all these nymphs were in the incubator at the same time and for 81 days, and during that time they moulted a number of times, varying from 3 to 7. If we consider the number of times that each of those nymphs moulted in relation to the total number of moults it passed through, we find that those introduced into the incubator in stage 4 passed through half (5 out of 10 and 7 out of 12) their total number of moults in the 81 days, while those introduced at later stages passed through less than half their total number—a fact which supports what I have already shown by two other methods, namely, that the stages tend to lengthen out as the nymphs advance.

Whether or not this lengthening out of successive stages is a phenomenon common to the larvæ of all insects has still to be shown, and I can find no reference to the subject, but it is interesting to note that Newport (1839) mentions that the rate of the pulse in the larvæ of *Sphinx ligustri* gets slower in successive stages—a fact which might well be correlated with the lengthening of the stages.

Leaving out for the present the question as to whether the winter warmth has curtailed the number of the stages, a point on which I have very little evidence, it is easy to show that the favourable conditions greatly curtailed the duration of the life of the nymph.

All the imagines from the winter-warmed nymphs appeared between April and July of the year following that in which the eggs were laid—that is, within 10 months. On the other hand, the imagines from the nymphs which were in ordinary laboratory temperatures during the winter, with one exception, appeared a year later than the others, more than 20 months after the hatching of the eggs, and in spite of the incubation from April to July. In connection with these two extremes, the three cases of nymphs which for 21 days in February enjoyed the warmth of the incubator are most interesting. In all other respects they were treated exactly like the second batch of nymphs—that is, they endured ordinary laboratory temperatures until April 20th, and then were in summer temperature,—yet they all three hatched out with the first batch, one in June, one in July, and the third in August. It is certainly interesting that three weeks' warmth in February, during which each nymph moulted twice, should have made a difference of more than 10 months to those three nymphs; and since temperature has such a marked effect it may be possible to account for the periodic swarms of dragonflies on the ground that a specially mild winter in some region may bring on a batch of nymphs, so that the imagines appear a season earlier than under normal circumstances. In such a case the batches of 2 years would appear together, and might be a prelude to a migration.

I cannot account for the single individual which, without any winter warmth, emerged with the first batch of nymphs. It is possible that it was in the incubator with the other three in

TABLE 4.

No.	Nymphs in incubator from Dec. 7, 1906, to Feb. 26, 1907.		Nymphs in incubator for 21 days in Feb. and again from April 20, 1907.		Nymphs left cold through winter. Incubated from April 20, 1907.	
	Imagines hatched out.	No. of Stages.	Imagines hatched out.	No. of Stages.	Imagines hatched out.	No. of Stages.
1 ...	<i>A. pulchellum</i> , Apr. 15, 1907.	X.	<i>A. pulchellum</i> , June 5, 1907.	X.	<i>A. pulchellum</i> , June 5, 1907.	X.
2 ...	" June 2, "	X.	" July 22, "	XI.	" May 24, "	XIII.
3 ...	" " 12, "	XII.	" Aug. 8, "	XI.	" " 10, "	XIII.
4 ...	" " 14, "	XII.			" " 21, "	XI.
5 ...	" " 21, "	X.			" " 24, "	XI.
6 ...	" " 24, "	XII.			<i>E. cyathigerum</i> , May 14, "	XIV.
7 ...	<i>I. elegans</i> , Apr. or May, "	XII.				
8 ...	<i>P. nymphula</i> , May 11, "	XII.				
9 ...	" June 6, "	XI.				
10 ...	<i>E. naïas</i> , July 22, "	XIV.				

February, as it moulted once during that period, but so far as my records go it was not!

Table 4 (p. 272) gives the dates of appearance of the imagines and also the number of stages through which the nymphs passed.

With regard to the question whether a high temperature in winter tends to reduce the number of stages in the life of the nymph, the material is too scanty to form any sound opinion. For such a question only one species can be considered at a time, as probably all species do not moult the same number of times under similar conditions. Also the individuals of any one species will not, under apparently similar conditions, all moult the same number of times, so that the average of a fair number of individuals would be necessary to get any definite result.

With regard to *Agrion pulchellum*, the only thing that can be said is that, with the single exception already referred to, the only nymphs which completed in 10 stages were three which had been incubated during the winter, while the only ones which passed through the 13 stages were two which had been kept cold during the winter. On the other hand, three of the winter-warmed nymphs passed through 12 stages, while two of the others got through in 11; and I am inclined to think, after studying the rate of growth, that the incubator did nothing towards reducing the number of stages. I shall discuss this in relation to the question of body-length.

BODY-LENGTH.

The average length of a nymph of *Agrion pulchellum* in its final stage is 18.0 mm., the smallest nymphs being about 14.0 mm. and the largest about 22.0 mm. These figures were obtained by measuring a number of nymphs with 7-segmented antennæ collected without any regard as to the number of stages they had passed through, and they show a wide range of variation in size. In the newly-hatched nymphs there was but little difference in body-length, but at each succeeding moult the differences became more marked, so that, for instance, after the eighth moult, two nymphs measured respectively 6.7 mm. and 14.0 mm. In noting this fact I also noted that the smaller nymph passed through 13 stages, while the larger one completed in 10; and as the latter had been incubated during the winter, while the former had not, I at first thought that there would be evidence of reduction in the number of moults in the winter-incubated individuals. To test this I took the body-lengths of all the nymphs, so far as I had the figures, at each stage, and compared the length of each nymph in relation to the number of moults it ultimately went through, and the results are rather interesting and are given in Table 5 (p. 274). It will be noticed that the tendency all through is for the larger nymphs in any stage to be those which ultimately complete in the smallest number of stages; and since this is noticeable in the beginning of the second stage and becomes more marked in succeeding stages, it seems that the earlier stages

of the nymph decide its destiny as to the number of stages. Incubation, then, had apparently no effect on the number of stages which had been determined before incubation was resorted to, but it seems probable that if the nymphs had been incubated from the moment they hatched, the effect would have been different. That there is not complete regularity in the Table is perhaps not to be wondered at. A nymph may "stagnate" for a period owing to some upset of its metabolism, and that might cause it to fall behind for a stage or even longer, in which case the question arises whether a long delay would not possibly necessitate an extra moult? I will consider this point further when discussing the significance of the moult.

THE ANTENNÆ.

The segmentation of the antennæ has already been described. It is to be noted that the segment immediately above the scape, *i. e.* the third from the base, is the one which divides three times to produce new segments for the antenna, and that these divisions are, with a very few exceptions, definitely connected with certain stages in the life of the nymph. The actual formation of the new segment is not, of course, an instantaneous process, but takes place by slow degrees within the "shell" of the antenna, only becoming revealed when that shell is cast off.

It is interesting to note that in one of the Ephemeridæ, where development has been followed, Lord Avebury (1863 and 1865) found that the third segment of the antenna, the one next to the scape, is there also the centre of growth.

As the nymph increases in length the antennæ also grow, but these organs do not maintain a rate of growth proportionate to that of the body. Whereas in the first stage the antennæ are 23 per cent. of the body-length, the percentage gets steadily less as the nymph grows, until, in the full-grown individual, the antennæ are less than 12 per cent. of the body-length.

The growth in length of the antenna is not due to the gradual lengthening of each segment, but is chiefly due to growth of the region immediately above the scape. This is easily shown by taking the average length of the antenna at each successive stage and finding what percentage of that length is taken up by each segment. The results are shown in the accompanying chart (p. 276), from which it will be seen that, whereas segment 3 gradually increases its percentage of the length of the antenna, the scape and segments 4 and 5 only maintain a rate of growth proportional to that of the antenna, while segment 6 grows much too slowly to maintain its proportion to the total length.

Stages X., XI., XII., and XIII. may any of them be the last stage in the life of the nymph, and in finding the average length for each segment at each stage I had to exclude the "7-segmented" individuals in each of these stages, except XIII., where there were no "6-segmented" nymphs. For comparison I also found the percentage for the "7-segmented" condition in stages X., XI., and XII., and they are given as X. *a*, XI. *a*, and XII. *a*, and it will be seen that in each of them segment 3 is proportionately

longer than in the "6-segmented" condition. The average length of the "7-segmented" antennæ is also greater than that

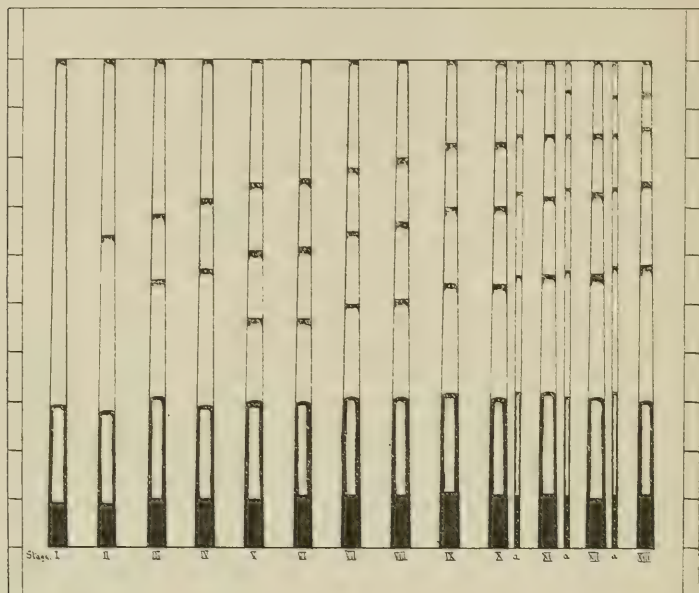


Chart showing the growth of the segments of the antennæ in *Agrion pulchellum* Lind. of the "6-segmented" antennæ for the same stage, indicating that the larger nymphs of the stage are those which are near their final ecdysis.

THE LAMELLÆ.

Like the antennæ, the lamellæ are much longer in proportion to the body-length in the newly-hatched nymph than in the full-grown one. Whereas they are almost the same length as a nymph of 1.3 mm., in a nymph of 17 mm. they are less than half the length.

The pointed linear organs of the first-stage nymph gradually widen out in the vertical plane and ultimately become leaf-like. In both *Agrion pulchellum* and *puella*, and perhaps in all species of this genus, they gradually lose their pointed appearance and become distinctly rounded at the apex. Not only have I observed this rounded character in nymphs reared from the egg, but I have repeatedly hatched out the imagines of both these species, and only those nymphs with rounded lamellæ produced Agrions. I mention this because Lucas (1900, pp. 281, 288) describes the lamellæ of *A. puella* as being always pointed, and says that those of *A. pulchellum* are apparently similar. He mentions, however, that some authors have described them as having rounded apices. The full-grown nymph with pointed lamellæ, which is otherwise almost (or quite ?) indistinguishable from the Agrions, is *Ichnura elegans*.

The lamellæ of *Agrion*—I have been unable to find a character to distinguish the nymphs of *A. pulchellum* and *puella* from one another—are indistinguishable at first from those of *Ischnura*, unless possibly by certain small patches of pigment; but about the 6th, 7th, or 8th stage, sooner or later, according to the size of the nymph, they have become sufficiently wide and rounded at the apex to distinguish them.

These organs, into which the lateral tracheal trunks of the body pass and in which they break up into minute branches, so that the whole lamella is filled with them, are said to have a respiratory function. I have already referred to the intermittent blood-stream in these organs. Whether it is correct to describe it as intermittent I am not sure, but I have several times noticed that in a nymph taken from the tumbler and placed under the microscope no circulation was to be detected until after the lapse of some time, and it has occurred to me that the circulation in the lamellæ was noticeable only when the air in the water was becoming exhausted.

These organs are not, however, indispensable, as the nymph can live quite well without them. In the final stage they are often without them, having apparently cast them off. In the earlier stages, however, if a lamella is removed it is replaced by degrees. If two or three days previous to a moult a lamella is removed, no replacement takes place until the second succeeding moult. As soon as the nymph escapes from the old skin, a very thin pointed sac, more or less circular in transverse section, is visible in place of the lamella previously removed. This sac is much smaller than the other lamellæ and contains at first no trace of tracheæ. It takes two, three, or even four moults before a new lamella is indistinguishable from the uninjured ones. The process of renewal is not sudden as it appears to be. The wound caused by removing a lamella is apparently quickly closed and the formation of the new lamella commences within the "shell," I believe at the time when a new nymph-skin is forming within the old one. Presumably it forms in a crumpled condition like the imaginal wings within the nymph wing-cases, and as soon as the pressure of the outer shell is released, the new lamella expands as a sac, becoming turgid owing to fluid entering it from the body.

A leg is replaced in the same way as a lamella, taking two or three stages to attain perfection, appearing immediately after the moult as a thin-walled sac which gradually thickens and hardens.

I have paid very little attention to the replacement of lost parts, but it seems to involve two processes: first, the formation of a thin-walled sac in the form of or tending towards the form of the organ to be renewed, and, secondly, a re-formation within the sac of the muscular and tracheal systems.

WING DEVELOPMENT.

I have already mentioned that the first sign of the pleural ridges appears after the nymph has completed its third or fourth

moult. This statement is true of *Agrion*, *Ischnura*, and *Pyrrosoma*, and may be true of *Enallagma* and *Erythronna*, but I imagine that in these cases wing-development begins rather later. These ridges lie diagonally across the second and third thoracic segments on either side of the tergum, and are the result of the upward growth of the pleura of the meso- and metathorax.

The rate of development from the first differs somewhat in different individuals. In the stage succeeding that in which the ridges first appear there may be a small bud on the inner side of each ridge, representing the commencement of the "wing," or this may not appear until a stage later.

As the buds grow larger the ridges also develop, those of the mesothorax gradually spreading anteriorly over the tergum until they meet in the middle line. Posteriorly they do not approach one another, so that a triangular patch of the tergum is left exposed between them. The metathoracic ridges join on to the posterior edges of the mesothoracic ones, and taper away posteriorly towards the sides of their segment, the posterior margin of which they slightly overlap. Thus a large part of the tergite of the metathorax is left exposed. The "wings" develop in such a way that they lie more or less flat on the sides of the dorsum in the wedge-shaped depression between the ridges, and extend backwards over the anterior abdominal segments. Towards the end of the final stage, however, when the thorax of the imago is forming within that of the nymph, the "wings" are somewhat raised and tilted.

At each moult an advance in development is visible, but it differs very considerably in the earlier stages in different individuals. For instance, a condition when the anterior "wings" just overlap the posterior edge of the metathorax, and the posterior wings just cover the first abdominal segment, might represent the 8th, 9th, or 10th stages, apparently depending on the general body-growth of the nymph and the number of stages through which the nymph is going to pass. There is a distinct connection between the later moults and the proportion of increase in the length of the wings. For instance, if the anterior wings reach in one stage almost to the posterior margin of the metathorax, their increase at the next moult will be about 33 per cent. of their length. At the next moult the increase will be about 40 per cent., while at the next, whether the 10th, 11th, or 12th, &c., the increase will be about 50 per cent. This is a large increase, and is, in every case I have observed, evidence that the nymph has reached its final stage. The "wings" now cover the first three abdominal segments, and often extend halfway over the fourth, and any nymph found with such long wing-cases is in its last and generally its longest stage.

The last nymphal stage is characterized by these long "wings" and by the 7-segmented antennæ, and the one or two stages previous to that are fairly well-marked by the rapid growth of the wings. The first four stages in the life-history are also easily recognized by the state of the antennæ and of the mask. In my

experience it was, with only one or two exceptions, after the antennæ had become six-segmented that the nymphs showed such variation in their rate of progress even when under similar conditions.

RESPIRATION.

The caudal lamellæ have been described as respiratory organs, and have been called "caudal gills," but Dewitz (1890) pointed out that the nymph can live without them, and suggested that possibly a rectal respiration, similar to that of the Calopterigidæ and the Anisopterids, existed in the Agrionidæ also. In those forms, however, where rectal respiration is dominant, there is an elaborate arrangement of tracheæ in the walls of the rectum which is completely absent in the Agrionidæ.

Dewitz has shown that a stream of water does pass in and out of the rectum in the Agrionidæ, but from my observation it is a very weak one, nor is there any special apparatus surrounding the anus in this group to prevent ingress of foreign particles such as is found in the Anisopterids. If rectal respiration exists at all, it seems to me that it must be very slight and of but little importance, as I could not observe any increased number of contractions of the rectum in specimens of *Agrion* which had been deprived of their lamellæ.

In the absence of the lamellæ, I think the whole of the respiration must be carried on through the skin.

CONCLUSION.

The occurrence of a pronymph stage in the Odonata* is not unique. It has been observed by Pagenstecher (1864, p. 7) in *Mantis religiosa*, and occurs also in other Orthoptera [see Künckel (1890 (1) p. xxxvii, and 1890 (2) p. 657)], and in several other orders (Packard, 1898, pp. 583-585), and is no doubt more common than has at present been recorded.

The stage is apparently for the purpose of freeing a tightly-packed larva from the egg, the amnion, instead of breaking and remaining within the shell, continuing intact until after the larva is clear, and the amnion forms the pronymph skin.

In the Odonata the larva casts the pronymph skin in exactly the same way as it casts its skin in subsequent moults, and it appears that, in the other forms in which this stage has been observed, the amnion is got rid of in much the same way, except that, as a rule, a special ampulla exists in the thorax of the larva which, by swelling up, bursts the amnion in that region (Packard, *l. c.* p. 584).

Although the total number of moults may vary somewhat, there is an unmistakable connection between certain stages in the development of the nymph and certain moults. What I have said as to the growth of the antennæ, the appearance of the labial hairs, and the development of the wings shows this, especially in

* Exactly the same phenomenon occurs in *Sympetrum striolatum*, one of the Anisopterid dragonflies, where the pronymph stage continues for about 7 minutes.

the earlier stages, and it is possible that a large number of nymphs kept under uniform conditions might have caused the correspondence to have continued through every stage.

The correspondence between certain stages in development and certain moults has been observed in the larvæ of other insects. For instance, Acrydians moult five times, the wings appearing after the second moult and increasing quite definitely at each succeeding moult, the increase in the last stage being very great. "Besides the acquisition of wings there are slight differences at each moult both in structure and colour, besides size, so that we may always recognise the comparative age and the particular stage of growth of any individual" (Packard, *l. c.* p. 595). Lord Avebury (*l. c.* p. 62) noticed that the nymph of *Chloëon* "gradually attains its perfect condition through a series of more than 20 moultings, each accompanied by a slight change of form," and there are numerous other cases cited in works on entomology, but, by many authors, no notice seems to have been taken of these facts in discussing the question of the significance of the moult.

On this latter point various suggestions have been made, of which the simplest, and perhaps the oldest, is that the moults are necessary to enable the larva to grow. It is obvious that where a larva is encased in a hard integument, one of two processes is necessary in order that the contained organism may increase in size. Either the integument must be capable of expanding with the organism, or it must be cast off from time to time.

When the nymph moults it expands greatly in size as it creeps out of its old skin, and, a few minutes after escaping, is much larger than the skin from which it emerged. The nymph has therefore been in a state of compression within its skin previous to the moult. But growth does not only take place at the moment of the moult—for instance, a nymph measuring 11 mm. at the commencement of its final stage was 15.2 mm. at the end of it, so that the nymph-skin is undoubtedly capable of expansion.

On the other hand, Dr. Sharp (1895, p. 163) considers that growth is only of secondary importance in accounting for the moult, urging as one reason that "many insects make their first ecdysis almost immediately after they leave the egg"; and he quotes the case of the blowfly larva, which, "according to Lowne, moults within two hours of its emergence from the egg." The case of the dragonfly pronymph is even more apt in this connection.

Eisig (1887, p. 781) suggested that the moult was for the purpose of getting rid of waste nitrogenous matter, and Dr. Sharp (*l. c.* p. 163) adds that it may be of importance in separating the carbonaceous products from the blood. Bataillon (1892, p. 61; 1893, p. 18) has stated that at the period of the moult the larva is in a state of asphyxiation; and Dr. Sharp (*l. c.* p. 131), referring to this observation, remarked that if it is a fact, "the secretion of the new coat of chitin may figure as an act of excretion of considerable importance."

The method of passing to the integument certain waste

products of the metabolism is almost universal throughout the animal kingdom, and there seems no reason why it should be regarded as, in insects, a special process of excretion. Whatever may have been the primary cause, the process has apparently been seized upon by Natural Selection, which has eliminated the less protected individuals, and produced a tough protective exoskeleton.

Bataillon's observations do not seem to me as important as Dr. Sharp regards them in demonstrating that the moult is a special act of excretion. When it is remembered that the larva, immediately after a moult, is soft and helpless, unable to feed, and an easy prey to almost any hungry animal, it is possible to believe that those individuals which did not quickly produce a new protective armour were eliminated in the struggle for existence. In order to quickly produce a new hard skin, a larva would necessarily retain a large amount of waste products which would otherwise pass out of the system, and this might account for an asphyxiated condition immediately prior to the moult.

Pantel (1898) considered the moult as necessary to account for the formation of ectodermal organs, and points out that, at each of the three stages of the larva of *Thrixion*, new characters appear; while Packard apparently held much the same view, as he says (*l. c.* p. 615), "the swollen bodies of the gravid female of *Gastrophysa*, *Meloë*, or of *Termites* and of the honey-ant show that the skin can stretch to a great extent, but in the metamorphoses of Crustacea and of Insects, the young of which are more or less worm-like or generalised in form, with fewer segments and appendages, or with appendages adapted for quite different uses from those of mature life, the necessity for a change of skin is seen to be necessary for mechanical reasons. Hence Crustacea and Insects moult most frequently early in life, when the changes of form are most thoroughgoing and radical, while simple growth and increase in size are most rapid at the end of the larval life, as seen in both shrimps and crabs, and in insects."

Now it seems to me that the fact that the larva is in a state of compression within the old shell at the time of the moult, suggests that the moult is necessary for growth, while the fact that certain stages of development are correlated with certain moults suggests that the moult is necessary for development, and I am inclined to think that a moult may be either a "growth-moult" or a "developmental moult," or a combination of the two.

Growth and development are, to some extent at least, independent phenomena, since we find variations in size in equally mature individuals, and apparently either growth or development may be retarded without the other being affected, at any rate to the same extent.

From the fact that certain stages in the life-history of a larva are correlated with certain advances in development, growth cannot possibly control the moults producing those stages, and they must be primarily "developmental moults." Further,

assuming that there are ectodermal developments to take place, it seems to me that so long as those developments do not take place in stages of excessive length, development will always be the controlling factor.

From the time of the moult the new ectoderm of the nymph is steadily hardening (probably oxidizing), and gradually losing its elasticity. As soon as the skin has ceased to expand with the growth of the nymph, the pressure on the body of the nymph reacts so that a new layer of chitin is laid down within, and separate from, the old layer. Once this new layer has completely isolated the old one the latter becomes brittle, and gives way along a line of weakness in the median line of the thorax when the nymph exerts itself and escapes. Such would be the explanation of a "growth-moult" pure and simple. If, however, previous to this condition being reached a developmental stage had been arrived at, a moult will take place which will serve both purposes, but will have been caused by developmental requirements.

In the case of one of my nymphs two moults took place within 4 days of each other. The second moult could not have been required for growth nor, on the excretion theory, for excretory purposes, and I imagine that the first moult was a "growth-moult" and the second a "developmental" one, especially as the first moult was the first to take place after the nymph had been put into the incubator, and 17 days after the previous one.

In this connection the effects of temperature on the number of moults are important. Packard (*l. c.* p. 616) refers to the experiments of Weniger and others on the larvæ of certain Lepidoptera, the results of which show that under warm moist conditions the number of moults is reduced from 5 to 4; and referring to certain other experiments, he says (p. 618): "As to the cause of the great number of moults in the arctians and in the beetles experimented with by Riley, it would seem that cold and lack of food during hibernation were the agents in arctians, and starvation or the lack of food in the case of the beetles, such cause preventing growth, though the hypodermis-cells retained their activity." W. H. Edwards states that larvæ of Lepidoptera which hibernate moult more often than those which have only a summer existence, and larvæ with a wide geographical distribution moult more often in cold than in warm regions. He also says "there seems to be a necessity with hibernators of getting rid of the rigid skin in which the larva has passed the winter; that is, if hibernation has taken place during the middle stages, as it does in *Apatura* and *Limenitis*. In these cases, very little food is taken between the moult which precedes hibernation and the one which follows it, and the larva, while in lethargy, is actually smaller than before the next previous moult. The skin shrinks, and has to be cast off before the awakened larva can grow" (quoted from Packard, *l. c.* p. 615).

Such a moult as that described by Edwards is apparently a "growth-moult" pure and simple. Unfortunately, however, it is not always so easy to determine the nature of a moult. Development involves a certain amount of local growth which presumably proceeds steadily between the moults. If a "growth-moult" is interpolated, the ectodermal structures will not remain as they were before the "growth-moult," but will show some advance as the result of that moult, so that, if in the ideal individual there are a definite number of developmental stages each showing a definite advance, the interpolated "growth-moult" upsets this state of things. But the developmental stages must get right again by the end of the larval period, so that there must be some power of adjustment; in other words, the interpolation of a single "growth-moult" will not necessarily add merely one moult to the life-history, but may necessitate one or more additional developmental moults for adjustment. The more normal moults in the life-history, the more probable it will be that the developmental stages will be complicated by stages for adjustment. The lengthening of the later stages of larval life, which Packard (*l. c.* p. 615) regards as chiefly growth-stages, seems to me to be a lengthening of the developmental stages owing to the more radical changes which they involve. The last stage of the nymph, for instance, in which the most marked internal changes take place is always a long one and corresponds with the pupal stage of the Holometabola.

The fact that certain moults have nothing whatever to do with growth (*e. g.*, of the pronymph of the dragonfly; of the subimago of Ephemera; moult to pupa and imago, &c.) seems fatal to a theory that growth is the cause of the moult, while the fact that certain moults have apparently nothing to do with development (*e. g.*, the moult of larvæ after hibernation) seems fatal to a theory which makes development the cause of the moult. Since, however, both causes seem to be at work, it is possible that both theories, combined and readjusted, may give us a true explanation of the significance of the moult.

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EXPLANATION OF THE PLATES.

PLATE XXXIII.

Development of Agrionid Dragonflies.

- Fig. 1. The egg of *Ischnura elegans* Lind., some hours before hatching.
 Fig. 2. Part of the same egg, at a later stage, showing the shell-rupture and the vesicle formed, and the head just commencing to move forward.
 Fig. 3. Part of the egg, at a still later stage, showing the head \times almost filling the vesicle. *a* is the point at which the membrane will rupture for the escape of the pronymph.
 Fig. 4. The pronymph immediately after its escape from the egg.
 Fig. 5. Prothorax, dorsal view, of the imago of *Agrion puella* L., ♀.
 Fig. 6. Prothorax, dorsal view, of the imago of *Agrion pulchellum* Lind., ♀.

PLATE XXXIV.

Development of Agrionid Dragonflies.

- Figs. 1, 2, 3 show the last stages of wing-development in the nymph of *Ischnura elegans* Lind., in this case stages 10, 11, and 12. The drawings are from the moulted skin.
 Fig. 4. The "mask" of *Agrion pulchellum* Lind., in the first stage, upper side.
 Fig. 5. One of the labial palpi of the same "mask" \times about 400.
 Fig. 6. The "mask" in the third stage.
 Fig. 7. The "mask" in the seventh stage, showing the palpi almost closed down on the anterior border of the labium. The stiff hairs are so situated that when the nymph is feeding they assist in holding the food, the mouth being situated just above *b*.

4. Growth-Stages in the British Species of the Coral Genus *Parasmilia*. By W. D. LANG, M.A., F.Z.S., British Museum (Nat. Hist.).

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(Text-figs. 38-46.)

I. CARRUTHERS' "PHASES" IN CARBONIFEROUS CORALS.

In the early numbers of last year's 'Geological Magazine' an article by R. G. Carruthers appeared on some simple Carboniferous Corals*. In it stress is laid on the necessity of cutting serial sections of corals and for the determination of species according to their growth-stages. It is shown that Carboniferous corals previously described as various species of *Zaphrentis* are really different forms of *Caninia cornucopiæ* Michelin, and that during development five "phases" can be recognised, occurring in the following order: (1) that corresponding with *Zaphrentis vermicularis* de Koninck; (2) with *Lophophyllum dumonti* Edwards & Haime; (3) with *Zaphrentis nystiania* de Koninck; (4) with *Zaphrentis edwardsiana* de Koninck; (5) with *Caninia cornu-bovis* Michelin.

It is important that the term "phase" is used to designate these forms and not the implicative "stage," and the reason is

* R. G. Carruthers, 1908, Geol. Mag. pp. 20, 63, & 158.

given:—"Save for the appearance of the dissepimental ring (a feature confined to the mature part of the corallum) none of the phases above described is truly ontogenetic, for, as will now be explained, they are intimately connected with the habits of growth of the corallum." This is only an expression of the common difficulty in the determination of species of any group, especially among fossils, the environment of which when alive is so uncertainly understood—that of knowing whether a given character is directly the result of heredity or caused by environment,

These "habits of growth" are shown to be the external shapes of the corallum at a given size, two shapes being mentioned, Trochoid and Cylindrical. And it is obvious from the examination of simple corals that a Trochoid or a Cylindrical shape-stage is always present, and if both, the former always precedes the latter. For simple corals, then, two definite shape-stages may be postulated; nor can the environment directly reverse the order in which they occur. Other growth-stages in the shape of the corallum may be found in simple corals; for instance, an Inverse-trochoid shape-stage occurs in some *Montlivaltia* following the Cylindrical shape-stage, and a Discoid shape-stage in other *Montlivaltia* as an episode in the Trochoid; but these need not here be considered.

So far as *Caninia cornucopie* is concerned, it appears that the environment determines the size reached by the corallum before it passes from the Trochoid to the Cylindrical shape-stage. If this were all, Carruthers' "phases" in *C. cornucopie* might be adopted unhesitatingly as "truly ontogenetic" growth-stages, and the determination of the species only complicated by the wide limits of variation of the diameter, so that a comparatively large specimen might be found in an early growth-stage, and *vice versa*. But it is stated that "it often happens that examples showing the long septa of the *dumonti*-phase are found to have the amplexoid septa," characteristic of the next—the *nystiana*-stage—"in their lower portions." This appearance of an older stage, earlier than, that is proximal to, a younger one, might seem to deny that the "phases" are growth-stages. The sequence in which the "phases" occur, however, is nowhere stated to be irregular, that is, haphazard and different in different individuals; on the contrary, except for the above modification, it is implied that the order of phases is in regular sequence. An explanation of the apparent irregularity is suggested by the behaviour of the costæ in the English species of Chalk *Parasmilia*, which alter in their ornamentation and general shape in a definite way when traced from the proximal to the distal end of the corallum.

Before describing these it may be said that Carruthers mentions other difficulties in the way of accepting his "phases" as true ontogenetic growth-forms. It appears that some internal characters change in correspondence with the change in general shape, others with change in the actual size of the corallum. Consequently, in extreme cases of non-correspondence between the size and shape

of the corallum, some internal characters at a given time will not be at the stage of development corresponding with the expected synchronous stage of the other internal characters. How far this is the case and how far it may be explained in the same way as the irregularity in the sequence of the costal ornamentation in *Parasmilia*, further work will show.

II. GROWTH-STAGES IN CHALK *PARASMILIA*.

The English species of Chalk *Parasmilia* are attached by their proximal ends to foreign objects. That this is an environmental rather than an hereditary character seems probable from the freedom and varying degrees of fixation in *Montlivaltia*, presumably of one species and from the same horizon and locality; for example, in *M. rugosa* Duncan*, from the *armatus*-zone of the Lias of Honeybourne, E. of Evesham, Worcestershire. It is conceivable that on a muddy sea-bottom a simple coral would find support in the mud around it, sufficient to hold it upright, while on a hard bottom it would have need to be fixed. The environment of the Chalk sea evidently required the *Parasmilia* to be attached to some hard object. Owing to their fixation, the proximal end spreads out to form a surface of attachment. So there is in *Parasmilia*, first a Peduncle shape-stage, next a Trochoid, and ultimately, in most, a Cylindrical shape-stage.

The English species of *Parasmilia* which have been up till now described fall readily into two divisions (see Table, p. 307), according to the nature of the costæ at the proximal end of the corallum. In one division the proximal end is smooth, that is the costæ on it are smooth and inconspicuous, or even hardly discernible, and only come into evidence in the Trochoid shape-stage; in no stage do they appear granular. In the second division the Peduncle or lowest Trochoid shape-stage is granular; the granules may appear dispersed irregularly or may fall into definite lines and tend to form irregular ridges, and in all cases they have become the costal ornament by the time the Trochoid shape-stage is reached. The first division contains the species *P. centralis* (Mantell) and *P. serpentina* Edwards & Haime. The described English species of the second division are *P. fittoni* Edwards & Haime, *P. granulata* Duncan, *P. gravesi* Edwards & Haime (Duncan's interpretation), *P. mantelli* Edwards & Haime, *P. cylindrica* Edwards & Haime, and *P. monilis* Duncan (as here interpreted). At first sight it is difficult to see any connection between the costæ of the first and those of the second division. But a detailed examination of the ontogenetic development of the costæ renders it likely that the primitive costal stages of the second division represent the adult costal stages of the first division. At any rate, non-granular stages precede the granular in the second

* P. M. Duncan, 1868, "British Fossil Corals," Mon. Pal. Soc. p. 58, pl. xvi. figs. 5-15. Compare, for instance, fig. 6 (B.M. no. R. 12043) with fig. 14 (B.M. no. R. 12051).

division. In each species the costæ, in passing from the proximal to the distal end of the corallum, exhibit very definite growth-stages; and these costal stages are dependent on changes in two characters—the general shape of the costa and its ornamentation.

The changes in the general shape of the costa are from a broad, low, indistinct, to a comparatively narrow, high, and clearly marked costa, and a corresponding katagenetic phase. The katagenesis* is nearly always rapid compared with the anagenesis*, and each is represented on the diagram, text-fig. 38, by a steep limb of the wave-like progression. It appears that thrice over in the series under consideration has this period of costal rise and fall been repeated, and each time with a different type of ornamentation.

When present, the ornamentation of the costa is of two kinds. In the most primitive stages the costæ are plain, or *very* slightly rough, and only change in height. This period is therefore here called the Plain Period (text-fig. 38). The first marked ornamentation is a longitudinal etching as if the costal surface had been corroded. As this becomes more intense, the ridges tend to mass together and fuse, until the highest development is a wavy ridge down the middle of the costa. Correlated with this etched ornamentation is a second period of costal rise, the broader lower costa having the irregular etching, and the high narrow costa the ridged ornament; this is the Etched Period. The second and more advanced type of ornament is the granule, and the Granular Period corresponds with a third costal rise.

Nine main stages may thus be formulated in this series of Corals, namely, a low, medium, and high stage in the Plain, Etched, and Granular Periods. Katagenetic stages have not been considered, because as a rule they are passed through too quickly to be appreciated. Of course, no one species of *Parasmilia* shows all nine stages; in fact the first three are so condensed in *P. centralis* (Mantell), one of the more primitive species, that a Plain Period would not have been suspected to have had a separate existence from the Etched Period, had not the scheme suggested it when the other stages were marshalled in order. A more careful examination of *P. centralis* (Mantell) then showed a heightening of the costa (costal-stage III.) before the normal low etched stage (costal-stage IV.), thus revealing a Plain Period, characteristic of *P. serpentina* Edwards & Haime, preceding the characteristic Etched Period of *P. centralis* (see text-fig. 40, F, G, p. 295). Such Tachygenesis† is, however, to be looked for when cases of individual development in other phyla are remembered. Again, the greatest gap in the series is between *P. centralis* (Mantell), the most advanced costal-stage of which is the high stage of the Etched Period (costal-stage VI.), and *P. fittoni* Edwards & Haime, the greater extent of whose costæ is in the low normal stage

* A. Hyatt, 1889, "Genesis of the Arietidae," Smithsonian Contributions to Knowledge, Washington, xxvi. Art. 2, pp. 71-74.

† A. Hyatt, 1893, "Bioplastology and the related branches of Biologic research," Proc. Boston Soc. Nat. Hist., vol. xxvi. p. 77.

of the Granular Period (costal-stage VII.). To detect and interpret the stages of the earlier parts of *P. fittoni* before costal-stage VII.

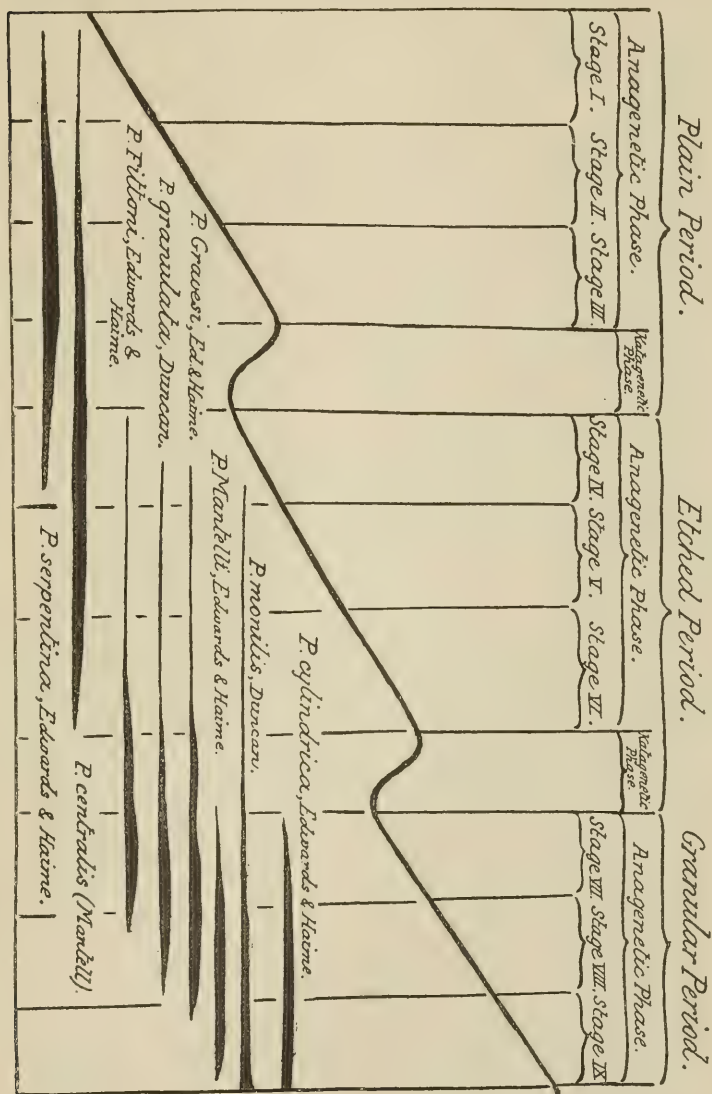


Diagram illustrating the progress of costal ornamentation in the English species of *Parasmittia*.

requires close observation. From this it will be realised how diagrammatically the case has been stated. But unless it is first

presented in its baldest and most diagrammatic aspect, the extraordinary regularity in the genetic sequence of the costal character may be lost sight of in the greater or less amount of development and condensation of the various characters, and in certain irregularities in their actual sequence due to environmental and other causes. One such case will be next considered.

III. RECAPITULATION OF GROWTH-STAGES AT REJUVENESCENCE.

The life-history of the costa in an actual specimen of each of the described forms of English Chalk *Parasmilia* will be given later on, that of the type-specimen when available, and in the cases where this is not in the British Museum, one of Duncan's figured specimens if possible. In two cases specimens are described which have no historical value in point of view of identification. But before describing these actual cases, an important modification in the regular sequence of growth-stages must be noted. Periodically in the growth of the corallum constrictions arise, marking points in the life of the coral when fresh growth took place after a period of rest. Such revivals of growth are known as Rejuvenescence*, a term very happily introduced, because the coral literally renews its youth at these points, and expresses the renewal by recapitulating earlier growth-stages in a condensed form; at least this is so in the costal characters of *Parasmilia*†. A glance at the actual costal life-histories given hereafter (see text-figs. 39-46) will show the extent of this recapitulation.

There is no reason for supposing that the recapitulation of younger stages at rejuvenescence is confined to the two characters observed, nor only to the genus in question; rather, it probably extends to the internal structure and is of general application. The anomaly then in *Caninia cornucopie* Michelin, described by Carruthers and mentioned early in this paper, may be explicable by this phenomenon. The coral had developed as far as the *nystiana*-stage, had next entered a period of rest, and on rejuvenescence, with renewed growth, had begun in the *dumonti*-stage, recapitulating its growth from that stage to the *nystiana*-stage again, and then proceeding, perhaps through further interruptions of rejuvenescence and consequent recapitulations, to the *edwardsiana*-stage.

IV. BERNARD'S THEORY OF THE NATURE OF REJUVENESCENCE.

It is difficult to dissociate rejuvenescence from branching when viewed in connection with recapitulation of earlier stages. Robert

* "Verjüngung-process," Milashevitch, 1876, Palæontographica, vol. xxi. p. 194-5. "Rejuvenescence," Tomes, 1882, Quart. Journ. Geol. Soc., p. 409; 1884, *op. cit.* p. 363; 1886, Geol. Mag., p. 394; 1888, *op. cit.* p. 208; 1899, *op. cit.* p. 305.

† It is the phenomenon here described that Bernard refers to in a footnote, British Museum Catalogue of Madreporarian Corals, 1906, vol. vi. p. 22.

Tracey Jackson * has shown how generally this takes place among plants and is exhibited by the leaves. In many plants these show progressive development when traced from the proximal to the distal end of the branch, and the stage at the proximal end is an earlier one than that of the leaf subtending that branch. A similar case has been suggested among Polyzoa, concerning the change in general shape of the zoæcium †. Reduced to its simplest expression, branching in corals is seen to become simple fission in the vertical plane, exhibited by such a form as *Thecosmilia* [*Chorisastræa*] *rugosa* (Tomes) *non* Laube ‡, which is only a *Montlivaltia* which has taken to division by fission; the *Montlivaltia*-stage of this coral is very near *M. painswicki* Duncan §, which comes from the same horizon and district—the Aalenian of the Cottesswolds. Another case is the specimen figured by Duncan as *Thecosmilia obtusa* || (d'Orbigny), which is only a *Montlivaltia fairfordensis* ¶ Tomes, which has begun to divide by fission; both come from the Bathonian clay of Fairford, Gloucestershire, and these forms as well as fully divided ones are common enough among the material from there. The examples quoted are exhibited in the British Museum, where all the specimens mentioned in this paper, unless otherwise stated, are to be seen. In some Cœlenterates fission normally occurs in the horizontal plane, resulting in the well-known phenomenon of strobilization. It is obvious that if horizontal fission were to occur in a coral, the upper product would obliterate the lower, since, having no means of locomotion, it would continue to grow in place and would secrete its skeleton on the top of the old **. That this new skeleton would be in strict continuity with the old is rendered likely by the soft nature of the secretory surface, which by its own weight would be moulded on the underlying old skeleton, and, when secreted, the new skeleton would reproduce the shape of, and so fit, the old. An interesting case showing this is afforded by a specimen exhibited in the British Museum (No. R. 9148) of the *Montlivaltia*-stage (*M. fairfordensis* Tomes) of *Thecosmilia obtusa* (d'Orbigny), growing on an oyster with a ribbed shell. The ribs of the oyster-shell are continuous with the costæ of the coral which has settled on it.

* R. T. Jackson, 1899, "Localised Stages in Development," Mem. Boston Soc. Nat. Hist. vol. v. no. 4, pp. 92, 131.

† W. D. Lang, 1905, Geol. Mag. pp. 259, 260.

‡ R. F. Tomes, 1882, Quart. Journ. Geol. Soc. p. 428; B.M. no. R. 10847.

§ P. M. Duncan, 1872, Mon. Pal. Soc., Part iii. p. 17, pl. i. fig. 12; B.M. no. R. 2305.

|| P. M. Duncan, 1872, Mon. Pal. Soc., Part iii. p. 14, pl. i. figs. 1-4; B.M. no. R. 8455.

¶ R. F. Tomes, 1883, Quart. Journ. Geol. Soc. pp. 181, 182, pl. vii. fig. 21; B.M. no. R. 8469.

** H. M. Bernard, 1906, British Museum Catalogue of Madreporarian Corals, vol. vi. p. 22.

V. REJUVENESCENCE AND TABULA-FORMATION.

Bernard*, who put forward this explanation of Rejuvenescence, goes further and suggests that tabula-formation has a similar origin. This is in direct contradiction to the generally accepted idea that tabula-formation is only a more complete form of dissepiment-formation; that whereas the latter only expresses a frequent and partial recession of the soft parts from the lower portion of the skeleton as the coral grew upwards, so tabulae express a periodic upward retreat of the soft parts as a whole. This may well be the origin of tabulae (dissepimental tabulae) in post-Rugose Madreporaria, the apparent tabulae of which in many cases seem to be modified dissepiments and often are seen to accompany the reduction of septa. This is so in a series of Bathonian species placed in various genera, but all allied to *Cyathophora* and *Cryptocænia*, of which a series is exhibited in the British Museum. These show the tendency to lose their septa and convert the interseptal dissepiments into tabulae. Intermediate forms occur between *Cyathophora pratti* Edwards & Haime, with well developed septa and few large dissepiments which tend to correspond with similar ones on the other side of the corallite, and *Astræa bourgeti* Defrance, in which the septa are only ridges and there are clearly marked tabulae. *Holocystis elegans* (Fittou), from the Lower Greensand, has tabulae and reduced septa, and the same is true of the Palæozoic Tabulate corals. That tabula-formation of this origin may have followed and replaced their formation from a transverse fission is possible; but the two methods are essentially distinct and mutually exclusive. The recapitulation of earlier stages might be used as a test to determine which cause is operative in any case, for there is no reason to suppose that it would occur merely on the upward movement of the coral in its skeleton; while it has been shown to occur as an accompaniment of rejuvenescence.

VI. ASTOGENY AND HISTOLYSIS.

Before leaving the subject of rejuvenescence connected with fission in a horizontal plane, it is interesting to note that Bernard† claims a similar behaviour in the coral colony to that in the individual. Colonies of corallites, he says (that is, whole corolla), undergo rejuvenescence, forming the well-known masses of coral in cake-shaped pieces piled one on the other (metamerically segmented, Bernard suggests), or else branched in regular order of repetition. And he mentions an observation by Duerden‡ of a living form which suggested that at the periods of rejuvenescence a general histolysis took place in the coral mass, representing collectively the fission of each individual. Again, the Polyzoa afford

* H. M. Bernard, 1906, *loc. cit.* p. 23.

† H. M. Bernard, 1906, British Museum Catalogue of Madreporarian Corals, vol. vi. top of p. 24.

‡ Duerden, 1904, "The Coral *Siderastræa*," Washington, Carnegie Institution (*vide* Bernard).

a parallel example of the behaviour of the colony as an individual. In these animals the whole zoarium (colony) undergoes growth-stages just as does the individual (zoecium). This was first pointed out in Polyzoa by Cumings*, and he termed the colonial developmental history Astogeny, as contrasted with the individual Ontogeny.

VII. INDIVIDUAL COSTAL LIFE-HISTORIES OF THE DESCRIBED SPECIES OF ENGLISH *PARASMILIA*. (Text-figs. 39-46).

[Note.—The letters B.M. in the following descriptions mean "British Museum." The stages in the life-history of the individual are lettered thus: A, B, C, . . . &c.; the costal-stages of the whole series; I., II., III., &c.]

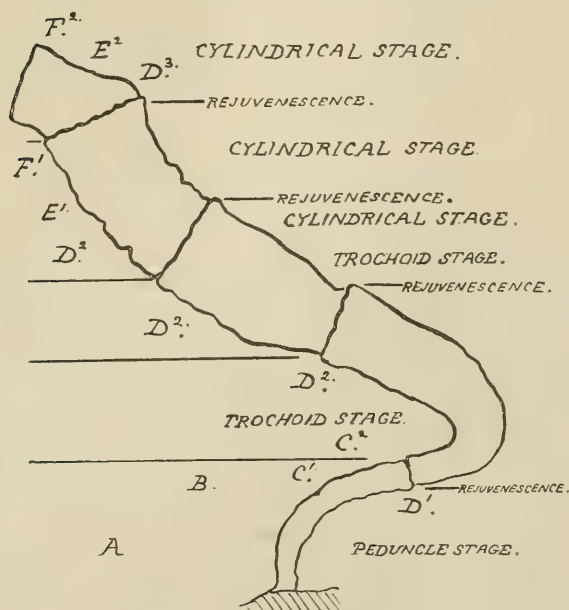
1. *PARASMILIA SERPENTINA* Edwards & Haime. (Text-fig. 39.)

Parasmilia (?) *serpentina* Edwards & Haime, 1850, "British Fossil Corals," Mon. Pal. Soc. p. 51, pl. viii. figs. 3, 3 a, 3 b.

Type-specimen, B.M. no. 48414.

Text-fig. 39.

PARASMILIA SERPENTINA,
Edwards & Haime.



Costal stages in *P. serpentina* Edwards & Haime.
Type-specimen, B.M. no. 48414. $\times 2\frac{1}{2}$.

* E. R. Cumings, 1904, American Journal of Science, series 4, vol. xvii. p. 49.

In this specimen the Peduncle, Trochoid, and Cylindrical shape-stages are all long and pass gradually from one to another, giving the corallum a regularly tapering shape. A rejuvenescence very early in life makes a convenient demarcation between the Peduncle and Trochoid shape-stage. The Peduncle being smooth for the first quarter of its course, there is a Precostal stage (text-fig. 39, A). Low plain costæ (text-fig. 39, B, costal-stage I.) succeed, and reach nearly to the first rejuvenescence; but just before this the costæ become higher (text-fig. 39, C¹, costal-stage II.), and are almost ridged (text-fig. 39, D¹, costal-stage III.) when rejuvenescence occurs. On resumption of growth the costæ are in costal-stage II. (text-fig. 39, C²), but rapidly pass again to costal-stage III. (text-fig. 39, D²), which is the characteristic stage of the corallum as a whole, and continues to the distal side of the third rejuvenescence; that is, at the second and third rejuvenescences the recapitulation is so slight that costal-stage II. is not repeated. At about halfway between the third and fourth rejuvenescences there is a sharp katagenesis (text-fig. 39, E¹), marked by a lowering of the costa and the disappearance of the ridge. The costæ then take on an etched ornamentation (text-fig. 39, F¹, costal-stage IV.), but are thrown back again to costal-stage III. (text-fig. 39, D³) after the fourth rejuvenescence. The katagenesis and advance to costal-stage IV. is again repeated (text-fig. 39, E², F²), and then the corallum terminates. The Trochoid shape-stage passes insensibly into the Cylindrical between rejuvenescences two and three.

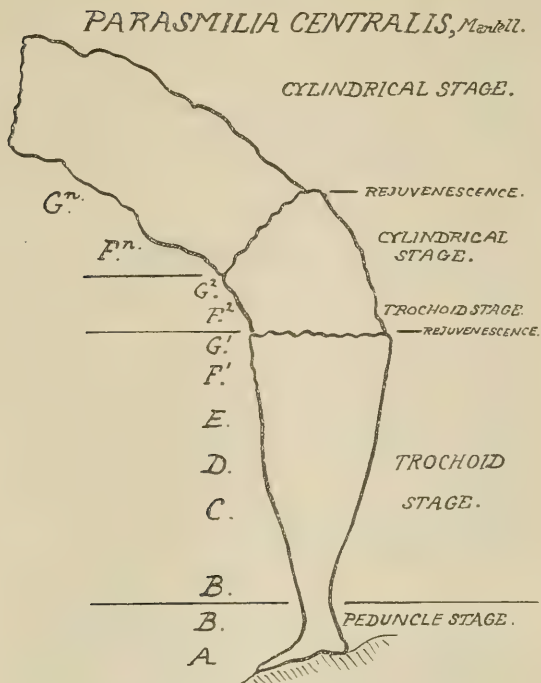
2. PARASMILIA CENTRALIS (Mantell). (Text-fig. 40.)

Madrepora centralis Mantell, 1822, "Fossils of the South Downs," pp. 159-160, pl. xvi. fig. 4.

Type-specimen, B.M. no. 5462.

On the expanded base of the type-specimen there is no appearance of costæ (text-fig. 40, A). This Precostal stage is followed by very faint, low, plain costæ on the Peduncle and lowest Trochoid shape-stages (text-fig. 40, B, costal-stage I.). By the mid-Trochoid shape-stage the costæ, though still plain (or *very* faintly roughened), have become more prominent and higher (text-fig. 40, C, D, costal-stages II. & III.). They then undergo a rapid katagenesis and appear low again, but this time markedly etched (text-fig. 40, E, costal-stage IV.). Shortly before the first rejuvenescence the costæ are heightened (text-fig. 40, F¹, costal-stage V.) and become ridged (text-fig. 40, G¹, costal-stage VI.). Between the first and second rejuvenescences the shape passes from Trochoid to Cylindrical, and costal-stages V. and VI. are repeated (text-fig. 40, F², G²); and though there is no definite rejuvenescence after the second, alternations of costal-stages V. and VI. occur (text-fig. 40, Fⁿ, Gⁿ) and show periods of growth alternating with fleeting rest-periods.

Text-fig. 40.



Costal stages in *P. centralis* Mantell.
Type-specimen, B.M. no. 5462. $\times 2$.

3. *PARASMILIA FITTONI* Edwards & Haime. (Text-fig. 41.)

Parasmilia fittoni Edwards & Haime, 1850, "British Fossil Corals," Mon. Pal. Soc. p. 50, pl. ix. fig. 2 (*non* figs. 2 *a*, 2 *b*).
Type-specimen, B.M. no. 48412.

In their Monograph on British Fossil Corals, Edwards & Haime state that *Parasmilia fittoni* is in the collections of the Geological Society, of the Geological Survey, and of the Museum at Paris. This species is not mentioned in Blake's and Sherborn's list of types in the collection of the Geological Society; nor do the Geological Survey possess the types; while at Paris there is the specimen figured on pl. ix. figs. 2 *a*, 2 *b*, but not fig. 2. The British Museum specimen No. 48412 agrees with Edwards & Haime's description and exactly corresponds with fig. 2 (reversed in printing so that the figure is a mirror-reflection of the specimen) and evidently is one of Edwards & Haime's two types. It follows then that there are two syntypes of this species, B.M. no. 48412, pl. ix. fig. 2 of Edwards & Haime, and the Paris specimen figured on pl. ix. figs. 2 *a*, 2 *b*; nor is it certain without examination of

it comes in while the costæ are still high after costal-stage VI. (the High Etched) and katagenetic as far as height goes from costal-stage VI. towards the low costa of costal-stage VII. So far the katagenetic phases of each period have been inconsiderable, but the fall in height from costal-stage VI. to costal-stage VII. occupies much of the Trochoid shape-stage in the type of *P. fittoni*. In this specimen the peduncle is absent and the costæ on first appearing are in costal-stage VI., the High Etched stage. The earlier stages are seen in the B.M. specimen No. R. 6632, figured as *Monocarya centralis* Mantell by Lonsdale, 1850, in Dixon's 'Geology of Sussex,' pl. xviii. fig. 4. This specimen, unfortunately damaged in the Trochoid shape-stage, exhibits the earlier and later parts and agrees very closely with the type specimen of *P. fittoni*. The costæ when first visible are low and wide, but rapidly become narrow and high with an ornamentation consisting of massed granules (text-fig. 41, A, costal-stages IV.-V.-VI.). As far as this first high stage the ornamentation appears as merely a roughness and is considered as indicating the Etched Period. The Peduncle shape-stage may be looked upon as including the Plain and Etched Periods of costal development reduced by Tachygenesis to a mere rise in the costa accompanied by a roughening of the surface. Whether this is the true explanation or not, it is a fact that there is a period of costal elevation which has declined before the appearance of the typical granular ornament of *P. fittoni*.

On returning to the type-specimen B.M. no. 48412, it is found that the peduncle is broken off, so that the corallum begins in the lowest Trochoid shape-stage. The costæ when first clearly seen are high and narrow (text-fig. 41, B), but rapidly widen and become lower (C) until, by the middle of the Trochoid shape-stage, they are wide and low and by this time have assumed the typical ornamentation of the species, which is very small granules, individually separate (text-fig. 41, D', costal stage VII.). At first, with the high costæ, the ornament appears as a rough ridge, which, as the costa widens, becomes lower, resolves into massed granules and finally (costal-stage VII.) into granules individually separate. This katagenesis suggests a previous granular anagenesis, but the stages on the peduncle do not suggest this; they are etched rather than granular, and it is more probable that the granules of costal-stage VII. have appeared earlier than their appropriately shaped costa and have become massed and piled in consequence of the shape of the costa.

At about the mid-Trochoid shape-stage, before the costæ have reached costal-stage VII., the first rejuvenescence occurs. It does not, however, interrupt the progress of the costal stages by causing recapitulation. This and the next rejuvenescence are partial and only affect the convex side of the corallum, which, as a whole, is considerably bent.

Before the second (partial) rejuvenescence, the costæ become narrower and the granules begin to mass together (text-fig. 41, E¹,

costal-stage VIII.). On resumption of growth costal-stage VII. reappears (text-fig. 41, D²) succeeded by costal-stage VIII. before the third rejuvenescence (text-fig. 41, E²). This sequence is repeated before the fourth and fifth rejuvenescences (text-fig. 41, D³, D⁴-E³, E⁴). The fifth and sixth rejuvenescences are compound ones, several occurring in both cases in quick succession. In both, too, the costæ reach a more elevated condition and the massed granules tend to form a ridge before rejuvenescence occurs (text-fig. 41, F¹, F²). This stage is not advanced enough to be considered costal-stage IX., and does not recur in the corallum of this specimen though there is a seventh rejuvenescence. The fifth, sixth, and seventh rejuvenescences throw the costæ back to costal-stage VII

4. *PARASMILIA GRANULATA* Duncan. (Text-fig. 42.)

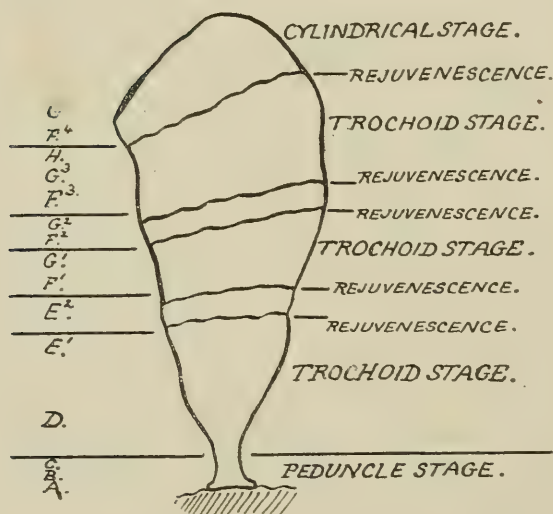
Parasmilia granulata Duncan, 1869, "British Fossil Corals," Mon. Pal. Soc. p. 13, pl. vi. fig. 5.

Monocarya centralis Lonsdale, 1850, in Dixon's 'Geology of Sussex,' pl. xviii. fig. 2.

Text-fig. 42.

PARASMILIA

GRANULATA, DUNCAN.



Costal stages in *P. granulata* Duncan.
Type-specimen, B.M. no. R. 6612. × 2.

Type-specimen, B.M. no. R. 6612. (The specimen figured in both the Plates referred to above.)

P. granulata very closely resembles *P. fittoni* Edwards & Haime, but costal-stage VII., the typical costal-stage of *P. fittoni*, is very reduced and replaced in importance by costal-stage VIII.; also costal-stage IX. is more nearly attained in *P. granulata*; otherwise the costal-stages closely correspond. But the katagenesis in the height of costa from costal-stage VI. to costal-stage VII. is even more prolonged than in *P. fittoni*, and the first appearance of granular ornament pushed back to costal-stage VI. The individual stages in *P. granulata* (text-fig. 42, A, B, C . . . &c.) will be described in order, so that the points above mentioned may be made clear.

A=Costal-stage IV. The Primary costæ are double, or longitudinally split. Costæ low; ornament etched.

B=Costal-stage V. Similar to stage A, but costæ of medium height.

C=Costal-stage VI. Primary costæ single and so for the remaining stages. Costæ high, narrow; massed granular ornamentation.

D=Costal-stage VII. for the ornament which is of individually separate granules, though not so separate as in *P. fittoni*; and katagenetic for the height of costa from costal-stage VI. to costal-stage VII.

E¹=Costal-stage VIII. for the ornament which is of massed granules, and katagenetic for the height of costa from costal-stage VI. to costal-stage VII.

First Rejuvenescence.

E². Similar to E¹.

Second Rejuvenescence.

F¹=Costal-stage VII. for both height of costa and ornament, *i. e.* a broad low costa and granules individually separate.

G¹=Costal-stage VIII. Costæ of medium height and breadth; granules massed together and tending to form a central ridge.

Third Rejuvenescence.

F² & G². A repetition of stages F¹ & G¹.

Fourth Rejuvenescence.

F³ & G³. A repetition of stages F¹ & F², G¹ & G².

H=Stage between costal-stage VIII. and costal-stage IX. Costæ high with thin wavy ridge, but massed granules are still evident.

Fifth Rejuvenescence. Trochoid shape stage ends and Cylindrical shape-stage begins.

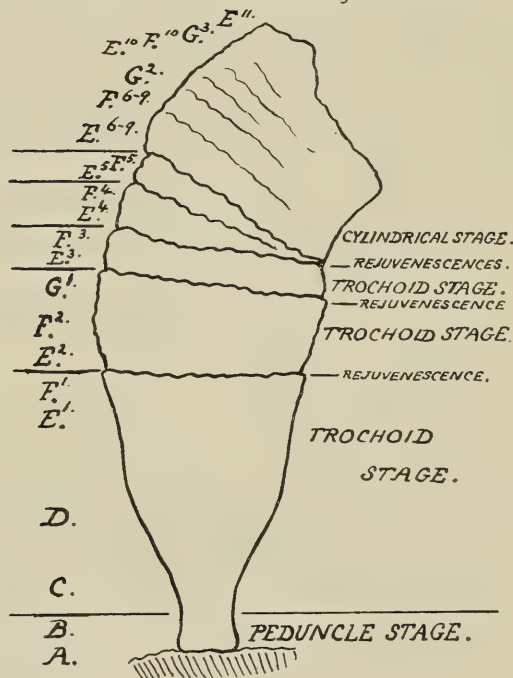
F⁴ & G⁴. A repetition of stages F¹ &c., G¹ &c.

5. *PARASMILIA GRAVESI* Edwards & Haime. (Text-fig. 43.)

Parasmilia centralis (Mantell), sub-species *gravesana* Edwards & Haime, Duncan, 1869, "British Fossil Corals," Mon. Pal. Soc. p. 12, pl. v. fig. 9.

In the absence of the type-specimen it is necessary to take Duncan's interpretation of this species, and the specimen he figured, B.M. no. R. 6616, is here described as *P. gravesi* Edwards & Haime, on the assumption that Duncan was correct in his determination.

Text-fig. 43.

PARASMILIA GRAVESI, Edwards & Haime.

Costal stages in *P. gravesi* Edwards & Haime.
Duncan's figured specimen, B.M. no. R. 6616. $\times 2$.

Specimen No. R. 6616 carries the modifications of *P. fittoni* exhibited in *P. granulata* still further. Costal-stage VII. (when once established for both height and ornament) is hurried through and hardly appears; costal-stage VIII. is important; and costal-stage IX. is actually attained. There is a very prolonged katabasis in the height of the costa from costal-stage VI. to costal-

stage VII.; and the first appearance of granular ornament is pushed back to costal-stage V.

At the extreme edge of the peduncle the costæ are low and have an etched ornament (text-fig. 43, A, costal-stage IV.). On the rest of the peduncle they are higher (text-fig. 43, B, costal-stage V.), but the ornamentation is resolving into granules. On the lowest Trochoid part of the corallum the costæ are high (text-fig. 43, C, costal-stage VI.) and the ornamentation is of individually separate granules and is the ornament of costal-stage VII. pushed backwards. The primary costæ are forked at this stage, the branches crossing neighbouring costæ (*cf.* stages A and B of *P. granulata*). From this point the costæ decrease in height and increase in breadth (text-fig. 43, D, katagenesis from costal-stage VI. to VII.) until past the mid-Trochoid shape-stage; here the costæ are broad and low with individually separate granules (text-fig. 43, E¹, costal-stage VII.), but immediately these mass and the costa becomes narrower and higher (text-fig. 43, F¹, costal-stage VIII.), and then rejuvenescence occurs. Between this and the second rejuvenescence costal-stage VIII. (text-fig. 43, F²) is dominant, but costal-stage VII. is just represented (text-fig. 43, E²) and costal-stage IX. (text-fig. 43, G¹) is just attained. Rejuvenescences 3, 4, and 5 cause the repetition of costal-stages VII. and VIII. (text-fig. 43, E³⁻⁵, F³⁻⁵) but not of costal-stage IX., and costal-stage VII. is only just indicated. The Cylindrical shape-stage has now been reached and a series of very slight constrictions indicates rejuvenescences 6, 7, 8, and 9, with a similar repetition of costal-stages VII. and VIII.; and before rejuvenescence 7 costal-stage IX. is repeated (text-fig. 43, E⁶⁻⁹, F⁶⁻⁹, G²). The repetition of costal-stages VII., VIII., and IX. (text-fig. 43, E¹⁰, F¹⁰, G³) precedes rejuvenescence 10, which is a large one, and the corallum ends in costal-stage VII. (text-fig. 43, E¹¹) which is assumed when growth recommences.

6. PARASMILIA MANTELLI Edwards & Haime. (Text-fig. 44.)

Parasmilia mantelli Edwards & Haime, 1850, "British Fossil Corals," Mon. Pal. Soc. p. 49, pl. viii. figs. 2, 2 a.

Type-specimen, B.M. no. 48413.

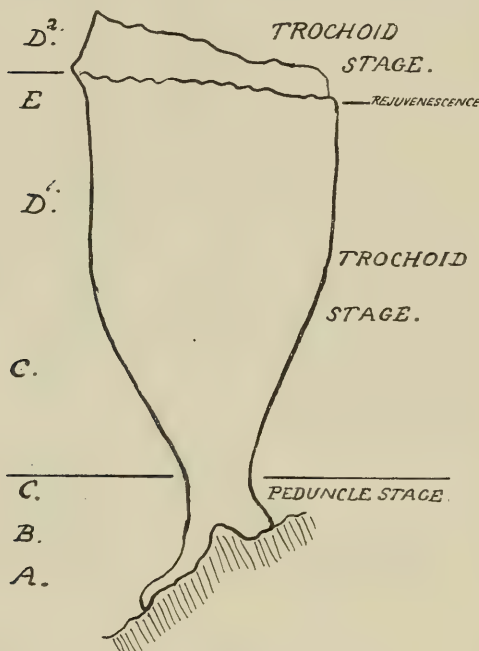
P. fittoni Edwards & Haime, *P. granulata* Duncan, and *P. gravesi* Edwards & Haime, form a group of closely allied species, progressing serially in costal development from a condition in which costal-stage VII. is dominant to one in which costal-stage VIII. is more important; and costal-stage IX. is hardly attained. Moreover, in this series there is always a long katagenesis after costal-stage VI. and before costal-stage VII. is attained. The group of *P. mantelli* Edwards & Haime, *P. cylindrica* Edwards & Haime, and *P. monilis* Duncan (as here determined) presents a series progressing from a condition with costal-stage VIII. to one with costal-stage IX. dominant, and though costal-stage VII. may be

represented, it appears, when present, immediately on the peduncle and without any preliminary long katagenesis from costal-stage VI. Also intercostal dissepiments occur on the three species of this group.

Text-fig. 44.

PARASMILIA MANTELLI,

Edwards & Haime.



Costal stages in *P. mantelli* Edwards & Haime.
Type-specimen, B.M. no. 48413. $\times 3$.

As soon as costæ appear on the peduncle of *P. mantelli*, they are low and ornamented with few large granules which tend to mass together (text-fig. 44, B, costal-stage VII., A is the pre-costal stage). The costæ then rapidly rise in height, become thinner and the granules become heaped in masses (text-fig. 44, C, costal-stage VIII.). At about halfway in the Trochoid shape-stage intercostal dissepiments occur; and from here to nearly the top of the Trochoid shape-stage the granules tend to disappear from the sides of the costæ and to form a ridge along their top (text-fig. 44, D¹, stage between costal-stages VIII. and IX.). At the top of the Trochoid stage the costæ have become high and thin with a sharp wavy edge, and the granules

have disappeared from their sides (text-fig. 44, E, costal-stage IX.); intercostal dissepiments are still present. Rejuvenescence now occurs and the corallum ends with resumption of growth in costal-stage VIII. (text-fig. 44, D"). Probably the Cylindrical shape-stage begins in this specimen after the first rejuvenescence.

7. *PARASMILIA CYLINDRICA* Edwards & Haime. (Text-fig. 45.)

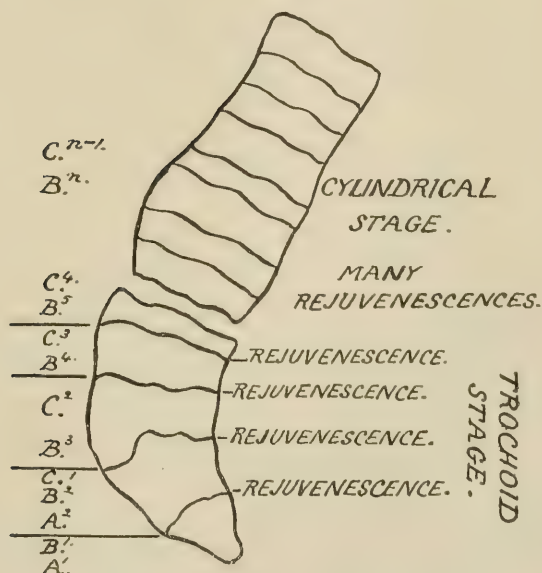
Parasmilia cylindrica Edwards & Haime, 1850, "British Fossil Corals," Mon. Pal. Soc. p. 50, pl. viii. fig. 5.

B.M. nos. R. 13889 & R. 6614.

Text-fig. 45.

PARASMILIA

CYLINDRICA, EDWARDS & HAIME.



Costal stages in *P. cylindrica* Edwards & Haime.
B.M. nos. R. 13889 & R. 6614. $\times 1\frac{1}{2}$.

The type-specimen of this species, from the Norwich Chalk, is stated, by Edwards and Haime, to have been in the "collection of Mr. J. S. Bowerbank." Though the Bowerbank Collection was acquired by the British Museum in 1865, this specimen has not been found. The species, however, is well-marked and easily

distinguished and specimens B.M. nos. R. 13889 and R. 6614, from the Norwich Chalk, are here described. Probably these two are the proximal and distal parts of one corallum; but as they do not exactly fit together, it is not safe to assume that they are one specimen, and the former is chosen as typical of the species, because it shows the early as well as the adult growth-stages.

The costæ are low when they first appear, with few, large granules tending to mass (text-fig. 45 A¹, costal-stage VII.), but soon become thinner with a crest of massed granules (text-fig. 45, B¹, costal-stage VIII.). The first rejuvenescence occurs very early in the corallum and throws the costæ back to stage VII. (text-fig. 45, A²), whence they rapidly pass to stage VIII. (text-fig. 45, B²), and again rapidly to stage IX. (text-fig. 45, C¹) which is characterised by high, thin, wavy costæ with no granules and with occasional intercostal dissepiments; the latter form an irregular ring round the corallum at the second rejuvenescence, which takes place low down in the Trochoid shape-stage. The costal history need be described in detail no further, as there is henceforth only a frequent alternation of costal-stages VIII. and IX., the latter being predominant and the former tending to disappear altogether in the Cylindrical shape-stage (text-fig. 45, Bⁿ, Cⁿ⁻¹).

8. PARASMILIA MONILIS Duncan. (Text-fig. 46.)

Parasmilia monilis Duncan, 1869, "British Fossil Corals," Mon. Pal. Soc. p. 12, pl. v. figs. 4, 5, 6.
B.M. no. R. 6477.

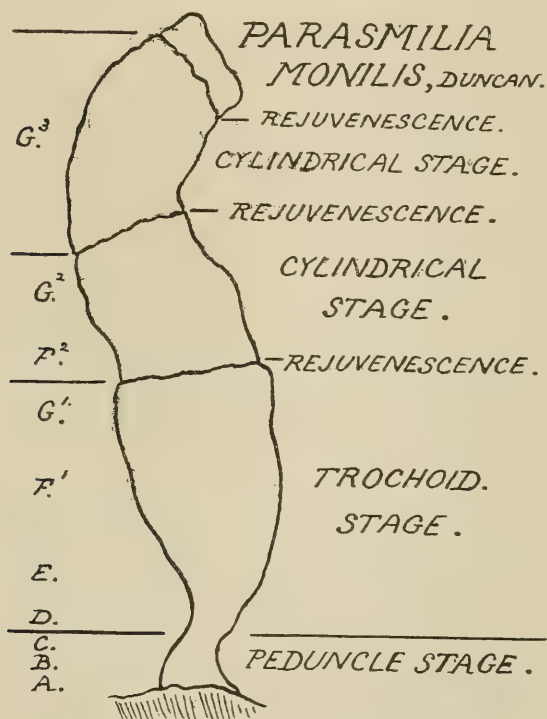
The determination of this species cannot be regarded as settled until the Type-specimen comes to light and has been examined, or its loss certified and a new Type chosen. It is not easy from Duncan's figure to see if intercostal dissepiments are present; they certainly do not appear in enlarged figured pieces of costæ high on the corallum; on the peduncle, of which there is also an enlarged drawing, they would not be expected.

A form represented by the B.M. specimen No. R. 6477 from the zone of *Belemnitella mucronata* Schlotheim, of East Harnham, Salisbury, from the Tomes Collection, is here described as *P. monilis*, as it closely resembles Duncan's figure. Small but numerous intercostal dissepiments are present in the distal part of the corallum, and it is chiefly the presence of these that makes the determination doubtful. Tomes' specimen is one of a series described by him as *P. mantelli* Edwards & Haime. There is also a specimen of *P. monilis* as here defined, B.M. no. R. 6618, figured in 1850 by Lonsdale in Dixon's 'Geology of Sussex,' pl. xviii. fig. 9, as *Monocarya centralis* (Mantell). This, however, has not been chosen for description as the whole of the proximal end is gone, and its exact horizon and locality are unknown.

P. monilis as here determined is remarkable for showing an

even more advanced type of adult costa than *P. cylindrica*, in the elimination of costal-stages VII. and VIII. from all but the most proximal part of the corallum; yet on the peduncle more primitive stages are shown than even *P. mantelli* exhibits, and in this *P. monilis* forms a link between *P. gravesi* (as Duncan interpreted it) and *P. mantelli*.

Text-fig. 46.



Costal stages in *P. monilis* Duncan.
B.M. no. R. 6477. $\times 3$.

At the base of the peduncle the costæ are low and rather rough (text-fig. 46, A, costal-stage IV.), but rapidly heighten (text-fig. 46, B & C, costal-stages V. & VI.). In this, the Etched Period, the primary costæ are longitudinally split (cf. *P. granulata* and *P. gravesi*). At the lowest part of the Trochoid shape-stage the costæ are low with few large granules (text-fig. 46, D, costal-stage VII.). These immediately mass together and the costæ rise in height (text-fig. 46, E, costal-stage VIII.) and by the time the mid-Trochoid shape-stage is reached, the granules have entirely vanished, the costæ are high with a thin, somewhat wavy ridge, and intercostal dissepiments have appeared (text-fig. 46, F¹, costal-stage IX.). A

further stage (text-fig. 46, G¹), in which the costæ are more wavy, occurs before the end of the Trochoid shape-stage. At this point the first rejuvenescence occurs, and on beginning growth again in the Cylindrical shape-stage the corallum is in stage F (text-fig. 46, F²), but rapidly passes to stage G (text-fig. 46, G²). After the second rejuvenescence the wavy G stage seems to have become permanently established, to the exclusion of stage F.

VIII. SUMMARY.

Perhaps too much stress has been laid upon what, after all, are only a few observations; but the points introduced are of such interest that it is hoped that they will be borne in mind and tested when work is done on Corals, and not lost sight of in the desire to describe new forms or to prove that too many already have been described. Summarily the points touched on are these:—Hereditary growth-stages exhibited in Rejuvenescence as evidence that the latter is a form of Fission, and subject to the same laws as other forms of Fission, such as Branching; views on the formation of Dissepiments and Tabulæ and Bernard's ideas on these in connection with Fission; their equal application to the colony as to the individual and a suggested relation with Histolysis; finally comparison with other widely different groups of branching organisms—Plants and Polyzoa, that laws of branching in one group may be compared with those in another and any law common to all may be determined.

NOTE:—Owing to the present inaccessibility of the collection of British Chalk fossils formed by Dr. A. Rowe, it has not been possible to test as fully as possible the stratigraphical value of these observations; but thanks to the kindness of Messrs. G. E. Dibley, C. P. Chatwin, and T. H. Withers, a certain amount of zonally-collected material has been available for comparison with the specimens here described. This, together with those of the British Museum specimens whose zone is known, has made it possible to draw up the following scheme of distribution in time. It will be seen that the order of forms arranged according to this distribution agrees on the whole with that deduced above from their structure.

P. serpentina, and forms resembling it: zone of *Holaster planus*—
Micraster coranguinum.

P. centralis, and forms resembling it: zone of *Holaster planus*—
Micraster coranguinum.

<i>P. fittoni</i> , <i>P. granulata</i> , <i>P. gravesi</i> , <i>P. mantelli</i> , <i>P. monilis</i> , <i>P. cylindrica</i> .	}	and forms resembling them; zone of <i>Micraster coranguinum</i> .
	}	Zone of <i>Belemnitella mucronata</i> .

[3rd April, 1909.]

TABLE CORRELATING INDIVIDUAL GROWTH-STAGES (A, B, C, . . .) WITH COSTAL-STAGES OF THE WHOLE SERIES (I., II., III., . . .).

N.B.—Where letters are not in continuous sequence (e. g. *P. fittoni*, A, D, E) the missing letters represent katagenetic stages.

	Pre-costal-stage.	Costal-stage I.	Costal-stage II.	Costal-stage III.	Costal-stage IV.	Costal-stage V.	Costal-stage VI.	Costal-stage VII.	Costal-stage VIII.	Costal-stage IX.
<i>P. serpentina</i> Edw. & H. . . .	A	B	C	D	F					
<i>P. centralis</i> (Mantell)	A	B	C	D	E	F	G			
<i>P. fittoni</i> Edw. & H.	×	×	×	×	A	A	A	D	E	
<i>P. granulata</i> Duncan	×	×	×	×	A	B	C	F	G, H	
<i>P. gravesi</i> Edw. & H.	×	×	×	×	A	B	C	E	F	G
<i>P. mantelli</i> Edw. & H. . . .	A	×	×	×	×	×	×	B	C, D	E
<i>P. cylindrica</i> Edw. & H. . . .	×	×	×	×	×	×	×	A	B	C
<i>P. monilis</i> , Duncan	×	×	×	×	A	B	C	D	E	F, G

TABLE FOR DETERMINATION OF ENGLISH SPECIES OF *Paramisilia*.

- A. Peduncle and lowest part of Trochoid shape-stage smooth or with faint, plain costæ; no granules; i. e. *costal-stage VII.* is not attained.
- I. Costæ over most of the corallum with sharp plain crest; i. e. *costal-stage III.* is dominant 1. *Paramisilia serpentina* Edwards
 - II. Costæ over most of the corallum with rough, irregular markings, but not granular; i. e. *Etched Period* is dominant. [& Haime.
 - 2. *Paramisilia centralis* (Mantell).
- B. Peduncle or lowest part of Trochoid shape-stage with granules; i. e. *costal-stage VII.* is attained.
- I. Granules are the costal ornament even in the most distal parts of the corallum, though the granules may be massed together; i. e. *costal-stage IX.* is not attained.
 - a. In the parts of the corallum with granular costæ the granules are mostly individually separate and the costæ low and broad; i. e. *costal-stage VII.* is dominant.
 - 3. *Paramisilia fittoni* Edwards & [Haime.
 - b. In the parts of the corallum with granular costæ, the granules mostly are more or less massed and the costæ comparatively high; i. e. *costal-stage VIII.* is dominant.
 - 4. *Paramisilia granulata* Duncan.
 - II. At the distal end of the corallum the costæ are thin, high and sharp and without granules; i. e. *costal-stage IX.* is attained.
 - a. Granules vanish from costæ only for short periods, before a rejuvenescence; i. e. *costal-stage IX.* is hardly attained.
 - 1. No intercostal dissepiments; a long katagenesis between *costal-stages VI.* and *VII.*
 - 5. *Paramisilia gravesi* Edwards & [Haime.
 - 2. Numerous intercostal dissepiments; *costal-stage VII.* immediately follows *costal-stage VI.*
 - 6. *Paramisilia mantelli* Edwards & [Haime.
 - b. Granules vanish from costæ over long stretches of the corallum; i. e. *costal-stage IX.* is easily attained.
 - 1. Costæ on the peduncle on the whole are low and inconspicuous with many granules; i. e. *costal-stage VII.* is well developed. Corallum is large, diameter in cylindrical shape-stage 15-20 mm.
 - 7. *Paramisilia cylindrica* Edwards & [Haime.
 - 2. Costæ on the peduncle on the whole are high and granules not scattered; i. e. *costal-stage VII.* is poorly developed. Corallum is small, diameter in cylindrical shape-stage 6-8 mm.
 - 8. *Paramisilia monilis* Duncan.

March 16, 1909.

FREDERICK GILLET, Esq., Vice-President, in the Chair.

The Secretary read the following report on the additions made to the Society's Menagerie during the month of February 1909 :—

The number of registered additions to the Society's Menagerie during the month of February last was 92. Of these, 50 were acquired by presentation, 2 by purchase, 28 were received on deposit, 2 in part exchange, and 10 were born in the Gardens.

The number of departures during the same period, by death and removals, was 134.

Amongst the additions special attention may be directed to :—

One Common Tapir (*Tapirus americanus*) ♂, from South America, and one Malayan Tapir (*Tapirus indicus*) ♀, from Malacca, received in part exchange on February 2nd.

One American Bison (*Bison americanus*) ♀, born in the Menagerie on February 27th.

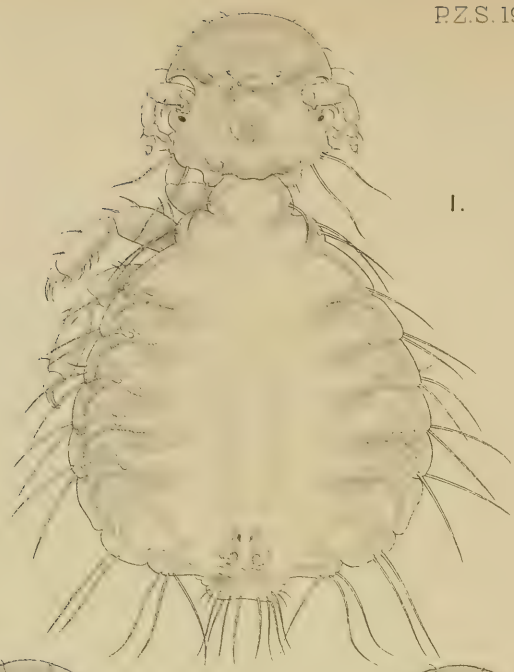
The Secretary exhibited, on behalf of Mr. E. C. Chubb, F.Z.S., the skins and skulls of two fœtal lions which had been presented to the Rhodesia Museum, Bulawayo, by Mr. A. Giese. They had been taken from a lioness which Mr. Giese shot last November at Dekka, about 50 miles south of the Victoria Falls.

These fœtuses showed very little pattern compared to that of newly born cubs; the black markings in each example of the former consisting only of a fairly well-defined median dorsal line, a mottling on the head, some distinct spots on the outer sides of the limbs, and a suspicion of rings on the tip of the tail.

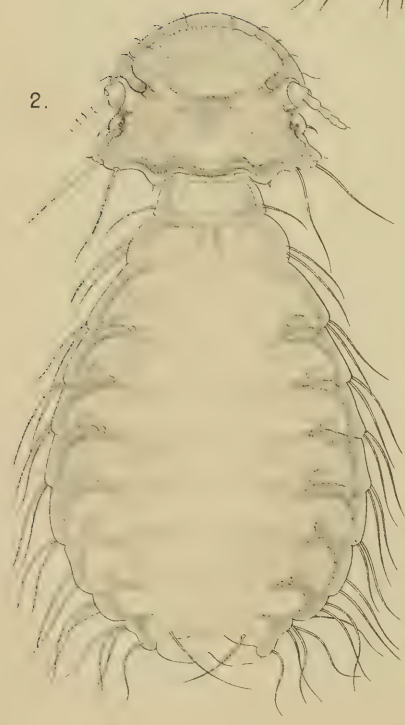
The Secretary exhibited a photograph of a young American Tapir, and called attention to the remarkable resemblance between that and the young Malayan Tapir, a photograph of which was reproduced in the Society's 'Proceedings,' 1908, p. 786. The longitudinal light stripes on the flanks of the body, the spots on the legs, and the white tips to the ears were present in both.

The Secretary called attention to an interesting paper by C. Onelli in the 'Revista del Jardin Zoologico de Buenos Aires,' 1908, p. 207, in which the author described a general correspondence between the number of vertebræ and the number of stripes or rows of spots in many mammals.

The Secretary exhibited a photograph of a small herd of Mountain Zebras (*Equus zebra*) in the possession of a dealer at Port Elizabeth, South Africa.



1.



2.



3.

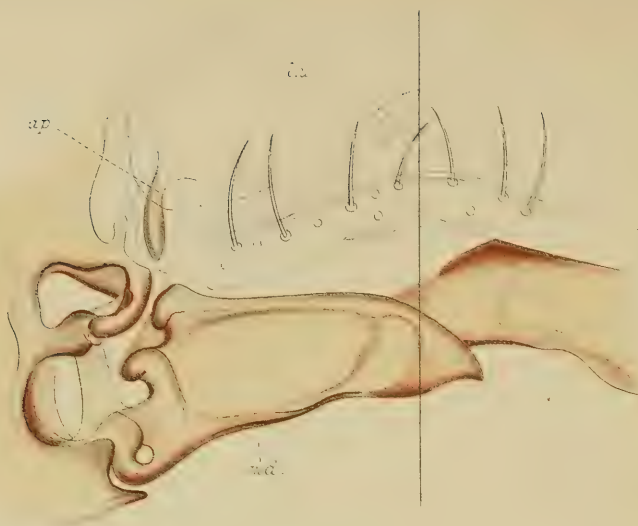


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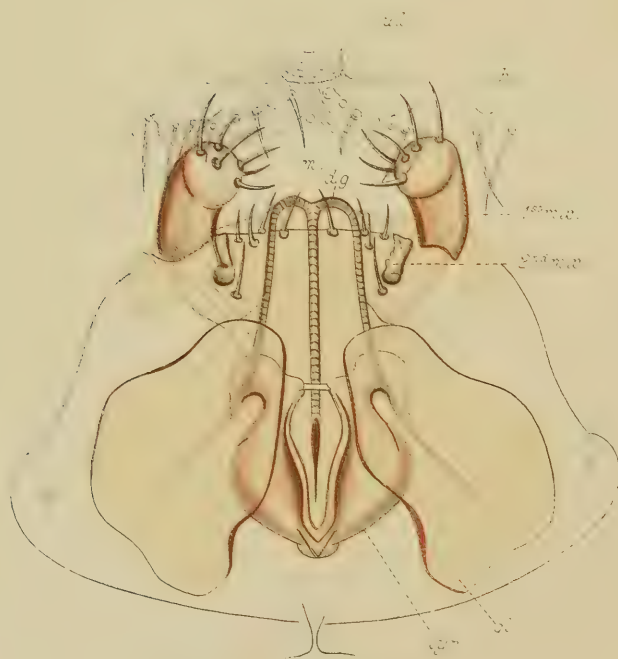


5. *lyr.*

E. Wilson, Cambridge.



6.

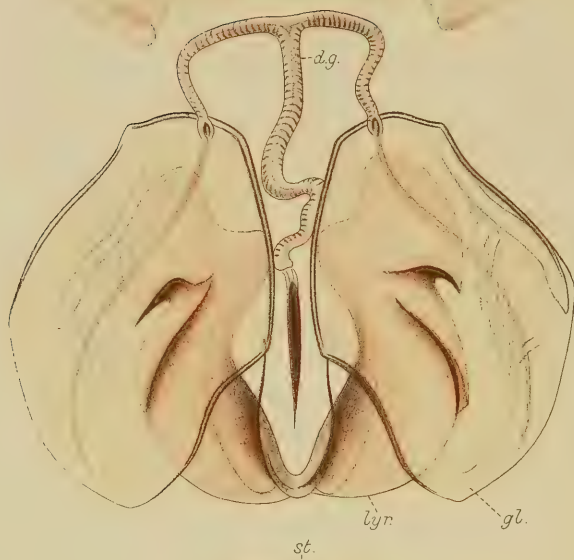


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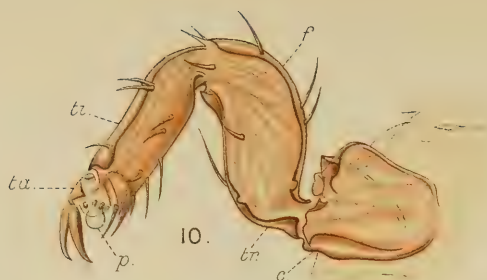
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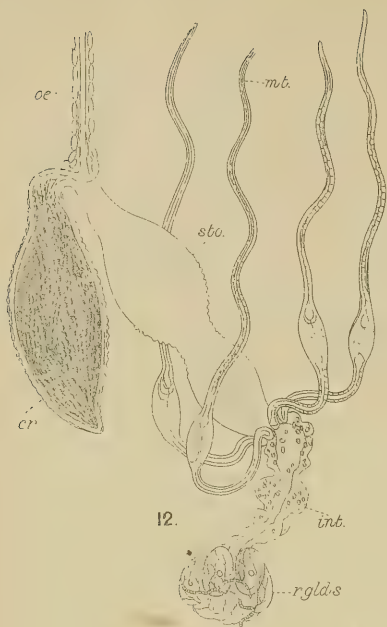
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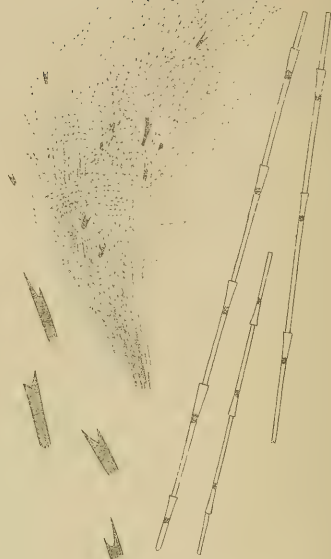
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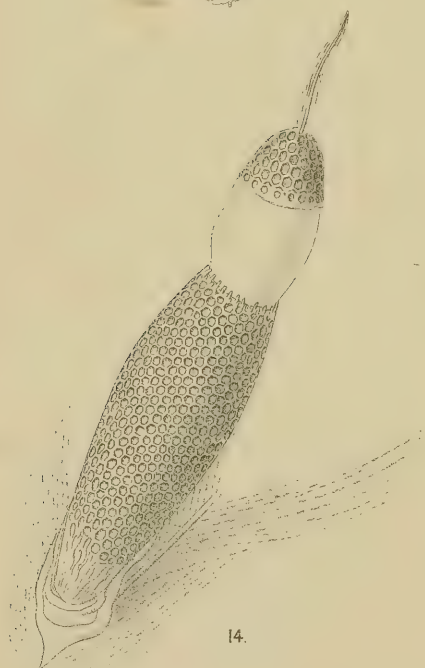




12.



13.



14.



15.

16.



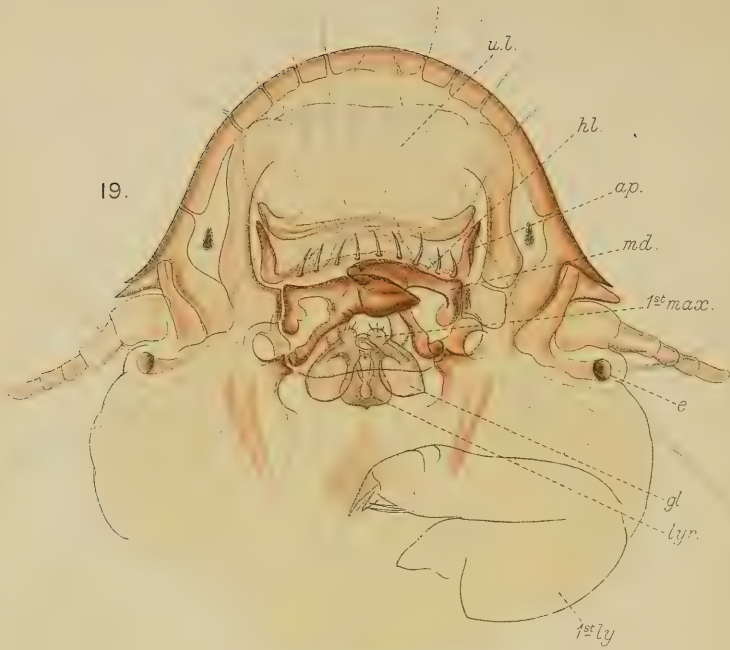
17.



18.



19.



A.

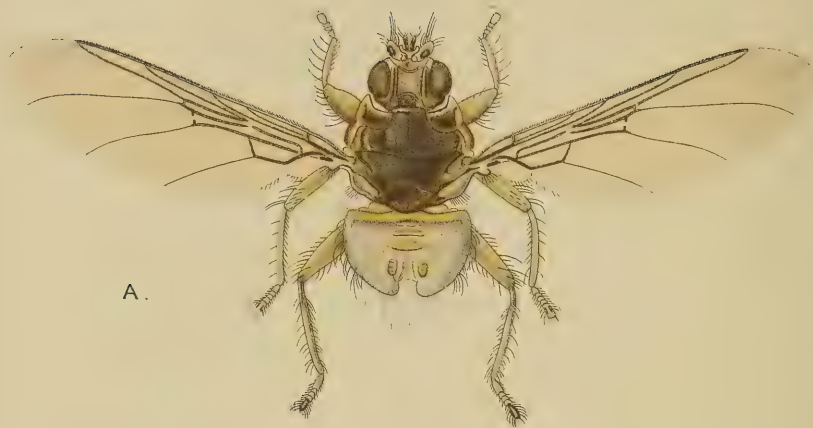
20.

B.

C.

NIRMUS CAMERATUS.

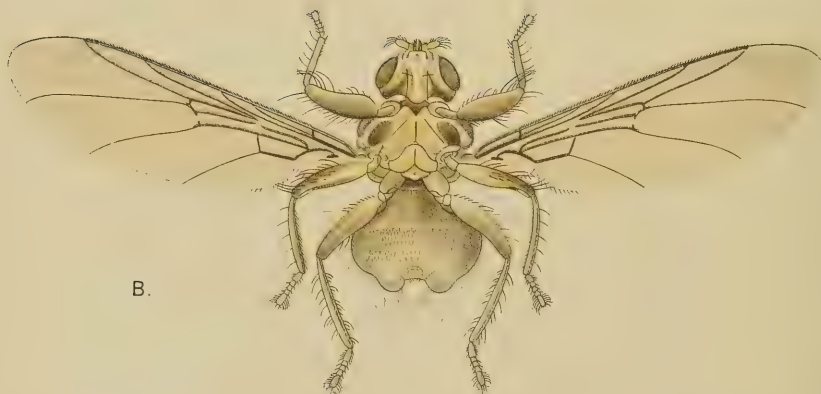
E. Wilson, Cambridge.



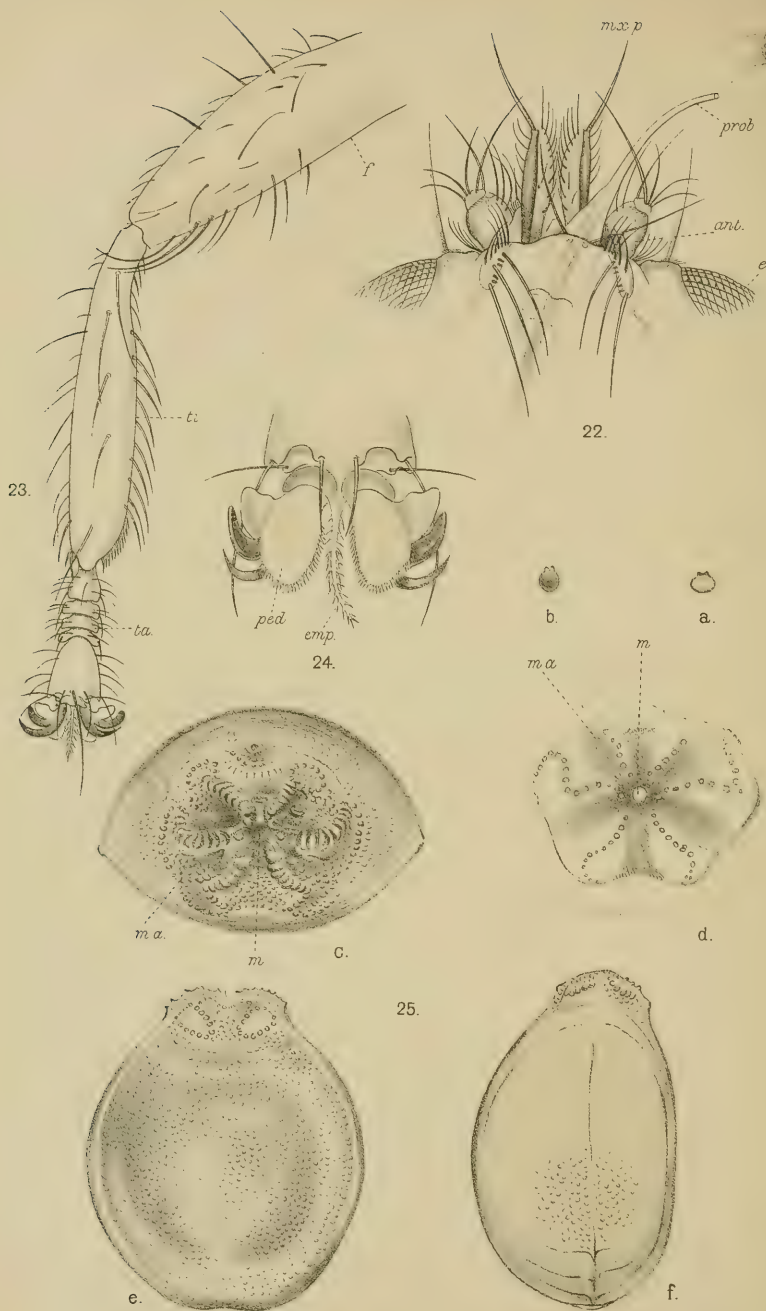
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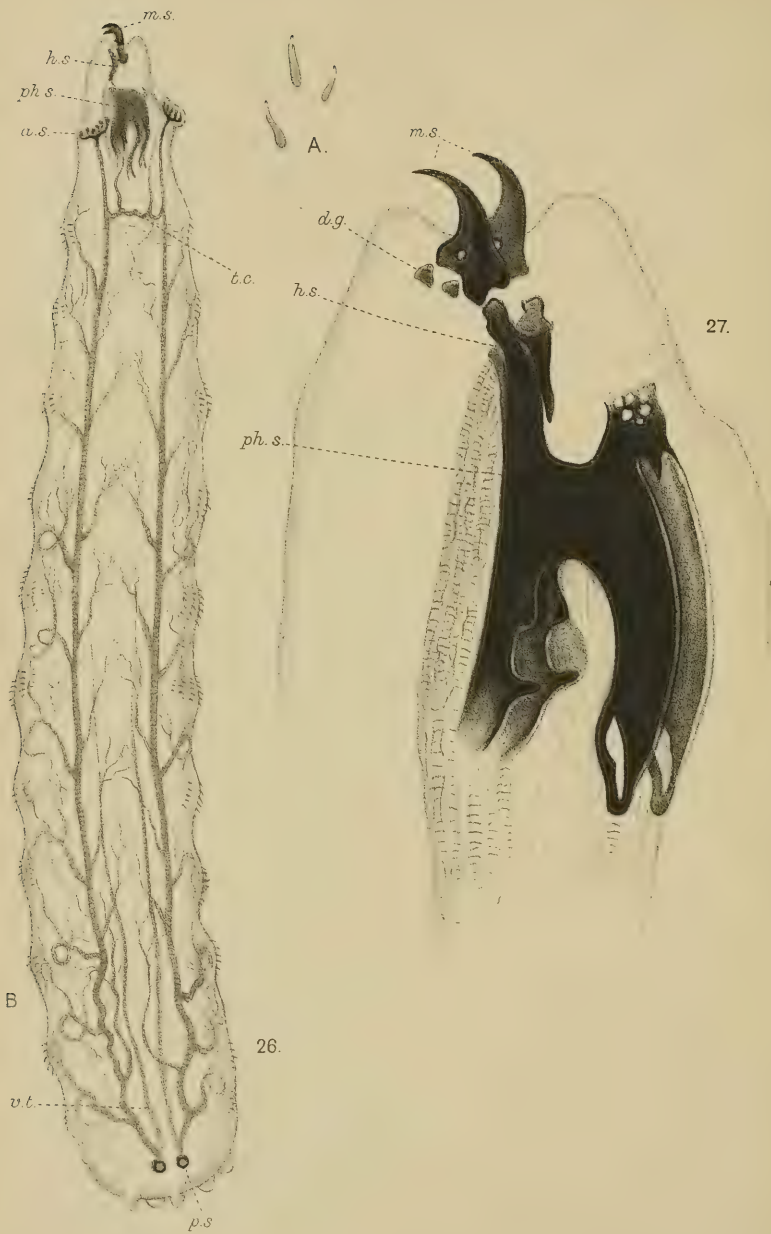


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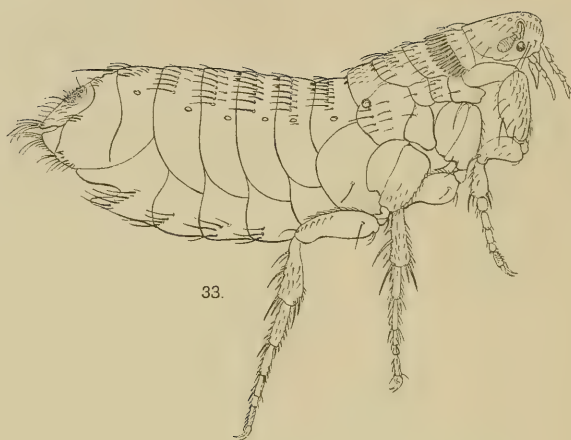




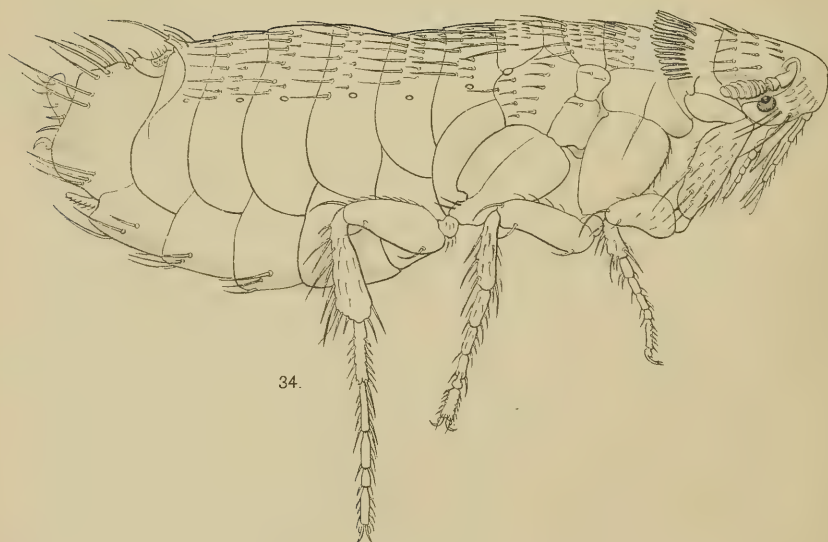
SCATOPHAGA STERCORARIA



SCATOPHAGA STERCORARIA.



33.



34.

The Secretary also exhibited a photograph of a female Giraffe captured in the West Soudan, east of Timbuctoo, showing a general resemblance with *Giraffa camelopardalis typica*.

Dr. F. A. Bather, M.A., F.Z.S., exhibited a fossil Echinoid, *Scutellina patella*, from the Eocene? (Barwonian) of Nelson, Glenelg River, Victoria, Australia, showing a marsupium for the young, as described by T. S. Hall (Proc. Roy. Soc. Victoria, n. s. xx. p. 140, 1908).

The following papers were read:—

1. The Ectoparasites of the Red Grouse (*Lagopus scoticus*).
By A. E. SHIPLEY, M.A., Hon.D.Sc., F.R.S., F.Z.S.,
Fellow and Tutor of Christ's College, Cambridge, and
Reader in Zoology in the University.

[Received November 28, 1908.]

(Plates XXXV.–XLVII.*)

I have made a careful examination of all the animals I can find recorded both from the outside and from the inside of the body of the grouse, with the exception of the blood parasites *Leucocytozoon lovati* Seligm. & Samb.†, the Protozoa found by Dr. Fantham, and the *Microfilaria* described by Sambon. Besides the Protozoa found by Sambon, Dr. Fantham has found a species of Spirochæte in the blood prepared from smears taken from the heart and liver. Probably this is a new species, as it is somewhat short and thick. It was only seen on two occasions. A second Spirochæte was found in the intestine. It was seen alive and was not numerous. It is possibly the so-called *Trypanosoma eberthi* (Kent). Oocysts of *Coccidium avium* are common in the intestine and rectum. Gregarine spores, probably of *Monocystis*, are sometimes seen in the intestine; *Monocystis* spores having been recorded by Pfeiffer from the intestines of birds. A Hæmosporidian occurs in the erythrocytes, but was seen only in the younger stages. They are rare. An *Amæba* is found both in the rectal contents and in the droppings.

The animals which live *within* the grouse constitute the Entozoa or Entoparasites, those that live on the body form the Ectoza or Ectoparasites, and with these latter this paper deals.

From the point of view of the Grouse Disease Inquiry the attention paid to the ectoparasites may seem superfluous, but many of the internal parasites and all the tape-worms pass through a second host. For example, the tape-worms which live in the alimentary canal of the grouse pass their younger or

* For explanation of the Plates, see p. 333.

† 'The Lancet,' 21 September, 1907, p. 829.

larval stages in the body of some lower animal. This lower animal, presumably an insect or a mollusc or a spider, must be eaten by a grouse and the larval tape-worm must be set free before the latter can grow up into the adult tape-worm which we find in the intestine of the grouse. In searching for this second host it was natural to begin with the ectoparasites, which one would imagine were continually being snapped up by the bird. We have, however, up till now completely failed to find any cestode-larvæ in the grouse-fly or in the numerous "biting-lice" or "bird-lice" (Mallophaga) which abound on the skin and amongst the feathers of the grouse; and, what is still more significant and still more remarkable, we have, in the hundreds of crop-contents which we have examined, never found one of these insects in the grouse's food.

This report is based in the main on my own observations, but some of the facts recorded were first observed by Dr. E. A. Wilson, and some by Mr. J. C. F. Fryer, of Caius College, Cambridge. In fact, in looking back over the work I find it difficult to disentangle the precise share each of us had in it. One thing, however, is clear. I am indebted to Dr. Wilson for a very large proportion of the drawings which have been reproduced in the Plates at the end of this paper, and I am also indebted to him for lightening many pleasant hours spent, not on the open, breezy heather of the Scottish moors, but in the stuffy laboratory we were wont to improvise in the back premises of many a Scottish inn.

To Mr. Edwin Wilson, of Cambridge, a word of thanks is also due for the accuracy and skill with which he has depicted the Grouse-fly and the Grouse-flea.

ECTOPARASITES.

INSECTA.

A. MALLOPHAGA.—Bird-lice or Biting-lice.

(i.) Fam. *Phloptæridæ*.

I.—*Goniodes tetraonis* Denny.

In his 'Monographia Anoplurorum Britanniae,' Denny* describes and figures this species, which he calls the "Louse of the Black and Red Grouse." He states that it is "common upon both the Black and Red Grouse" (*Lagopus tetrrix* and *L. scoticus*). "Upon the Willow or Hazel Grouse (*Lagopus saliceti*) I find a similar but distinct species, rather broader in the abdomen, and of much darker colour." Denny describes several species of the same genus which infest other game-birds.

* Published by H. G. Bohn, London, 1842, p. 161, pl. xiii. fig. 3.

Giebel* gives the name *Goniodes heteroceros* Nitzsch as a synonym of *G. tetraonis*, and in his large monograph on 'Les Pédiculines,' Piaget† uses the former name without any reference to Denny's. The name *G. heteroceros* also appears in Giebel's article‡ on the Epizoa of the Halle Museum, published in 1866, but only the name. In his article on "Parasiten" in von Middendorff's 'Reise in den Aussersten Norden und Osten Sibiriens,' Grube attributes certain bird-lice taken from *Lagopus albus*, the Willow Grouse, and from *Lagopus alpinus*, the Ptarmigan, to the species *Goniodes tetraonis* Denny; but Piaget points out certain differences, and seems to consider that a new species might have been described from these specimens.

Andrew Murray, in his book on 'Economic Entomology' §, writing of *Goniodes tetraonis*, says:—"This is the insect which sometimes, especially in the bad seasons, does so much harm to the young grouse when they are feeble and unhealthy."

It is the commonest of the insects which infest the skin of grouse, crawling about amongst the base of the feathers and on the vane of the feathers themselves. It occurs more commonly than *Nirmus cameratus*, which is often associated with it. It is comparatively rare to find a bird free from these "biting-lice," but perhaps 10 per cent. is about a fair estimate of the number of uninfested grouse. The number on each bird is to some extent an inverse measure of their health. Careful search will discover but two or three on a healthy grouse, but on a "piner" hundreds may be met with. This is not, however, the case with birds that die quickly of acute disease.

Goniodes tetraonis is usually found on the smaller feathers, crawling about halfway between their insertion and the tip of their vanes. When disturbed they hurry away into the brushwood of the small feathers, like small deer seeking cover, and they are by no means so easy to catch as one would at first think. They eat the finer barbules of the feathers, which, accumulating in the crop, gives the dark curved marking in their rather transparent bodies. On this meagre and arid diet they seem to flourish, actively produce young, and pass through several ecdyses.

The naked-eye colour of *Goniodes* is a yellowish brown. Under the microscope the body appears rather transparent, but wherever there is chitin this is of a yellowish to chestnut-brown colour according to the thickness. The crop, which is full of minute fragments of the finest barbules of the feathers, presents a blackish sac-like appearance, running obliquely across the middle line of the abdomen; a somewhat parallel but much smaller black tube represents possibly the rectum (Pls. XL. & XLI. figs. 12 & 16). In a few cases the œsophagus and crop presented a red appearance, this being probably due to hæmoglobin from the blood of the grouse.

* 'Insecta Epizoa,' Leipzig, 1874.

† Leiden, 1880.

‡ Zeitsch. f. ges. Naturwiss. xxviii. 1866, p. 387.

§ Chapman & Hall, London, 1877.

The body is, on the whole, flattened—especially is this the case with the head and abdomen. The thorax, as Snodgrass* points out in *Menopon persignatum*, appears to be triangular in cross-section.

The Head.—The head is shaped somewhat like the semicircular knives used for cutting cheese. The head of the female is somewhat broader and shorter than that of the male, and is produced at the posterior-lateral region into a much more prominent angle. In both male and female the angle bears a spine and a long hair. The anterior rim of the head is bounded by a thick rim of chitin, beneath which is a layer of granular protoplasm with a few nuclei, the hypodermis. At intervals the chitin is pierced by narrow channels, into which the hypodermis extends, and the chitin bears at the outer end of each of these channels a short hair (Pl. XXXVI. fig. 4). From the inner surface of this rounded anterior edge of the head a number of muscle-fibres pass radially inwards to a structure which has been called the upper lip, and which will be described later under this name. Just in front of the recess from which the antennæ arise, the anterior thickened chitinous rim curves to an end, being bent in and then out to form a short apodeme of which the inner end acts as the basis of articulation of the anterior limb of the stout mandibles (Pls. XXXVI. & XXXVII. figs. 4 & 6). The socket of the antennæ is also provided with a thickened chitinous skeleton, and across the base of the head, separating it from the prothorax, is a thickened plate which presents in profile the appearance of a bow; the rest of the head is enclosed in thin yellow chitin. The appendages of the head will be described later, together with those of the body.

There is no neck, but the first segment of the prothorax is only about one-half the width of the head. The mesonotum is fused with the metanotum and the thorax appears to have but two segments. There is, again, no waist or constriction between the thorax and the abdomen, but the segments from the first thoracic to the second or third abdominal gradually and uniformly widen, and then as uniformly diminish in width until the last. The separation of the first thoracic segment from the second is marked by a stout chitinous rim both dorsally and ventrally—this is, however, only found in this region; the rest of the segments are soft and not chitinized in the tergal and sternal regions, but the pleura are protected by well-marked chitinous shields, which, however, extend but a very short way dorsally and ventrally (Pl. XXXV. figs. 1, 2 & 3). In *Nirmus*, however, the lateral plates are more extended.

According to Sharp† the Mallophaga have from 8 to 9 abdominal segments, and according to Railliet‡ the family in which he places *Goniodes* has 9; but he remarks that the last

* Pap. Calif. Ac. vi. 1899, p. 145.

† Cambridge Natural History, vol. v. Insects, i. London, 1895.

‡ 'Traité de Zoologie Médicale et Agricole.' 2nd Edn., Paris, 1895.

two are sometimes completely fused, so that we only find 8 visible segments.

There are certainly only 8 visible in *Goniodes*, although *Nirmus* has 9 complete segments. The last visible segment in the female is a slightly bilobed plate bearing no hairs; the anus opens just below it. In the male the plate is not bilobed; it is stouter and bears a number of backwardly projecting hairs. Each segment, except the last in the female, bears a number of hairs; the arrangement of these is shown in the figures 1, 2, & 3, Plate XXXV.

The appendages are as follows:—

I. The eyes.—Each eye is formed of a little aggregation of pigmented cells, the whole somewhat cup-shaped, and of an almost spherical transparent thickening of the cuticle, the lens. The eyes are situated close behind the thickened cavity from which the antennæ arise (Pls. XXXV. & XXXVI. figs. 1, 2, 3, & 4).

II. The antennæ.—These arise from a deep hollow the chitinized walls of which are much thickened. The cavity practically conceals the proximal joint, which is broader than long; the second joint is the longest and is almost twice as long as its broadest part; the third, fourth, and fifth segments uniformly diminish in size, and the fifth or last bears at its end a number of bristles. The male is readily distinguished from the female by the fact that the third joint is produced into an inwardly directed process very like a thumb, and this gives the antennæ a biramous appearance (Pls. XXXV. & XXXVI. figs. 1 & 4).

The next three pairs of appendages are modified as mouth-parts, and in describing them we propose to mention certain median structures also connected with the mouth.

The most remarkable feature of the under surface of the head of a *Goniodes* is a white cushiony area with the outline of a stout sausage, sometimes described as the “upper lip” or “labrum.” It is bounded anteriorly by a ridge of chitin which takes its origin on each side from the inner face of the strong apodeme already mentioned. This cushion is covered with a multitude of rugosities, giving it the appearance of the skin of a dog-fish. There is always a more or less well-marked crease or groove across the long axis of the cushion, and the part posterior to the crease is supported by two longitudinal bars of chitin just as the double banners Temperance reformers carry in their processions are supported by the poles (Pl. XXXVI. fig. 5).

If one be watching the living *Goniodes* lying on its back on a slide, this cushion will be seen from time to time to swell up and scrape along the under surface of the cover-slip. Then it subsides again, possibly being pulled back by the numerous muscle-fibres which pass back from the anterior end of the head, and which appear to be inserted into the inner surface of the cushion. Along the posterior edge of the cushion is a small mobile membrane or lip which bears a moustache of eight hairs, shorter in

the centre, but increasing in length as one passes outward (Pl. XXXVI. fig. 5). This lip is frequently drawn down over the tips of the mandibles.

The only function one can suggest for the upper lip is that it acts as a scraping organ and it may be of use if the animal ever eats the epidermis of its host.

III. The mandibles.—These are by far the most powerful of the mouth-parts and are very strongly chitinized. The right and left mandibles are not exact images of one another, as the tip of one always closes outside the tip of the other, and thus there is a slight differentiation at the apex, which is so strongly chitinized as to be almost black. Each mandible is somewhat triangular in shape, the apex forming the tip. The articulation is very complex (Pl. XXXVII. fig. 6) and is mainly with the inner end of the powerful apodeme which runs in just in front of the base of the mandibles. A very powerful muscle runs into the external posterior angle of each mandible, the so-called condyle, and serves to bring it into biting contact with the other. The sharp shearing-edge of the mandible is admirably adapted for cutting off the barbules of the feathers which form the food of the biting-lice.

IV. The first pair of maxillæ.—These are very difficult to see in the living animal and are best observed when in movement. We agree with Grosse* in describing them as lobes without any traces of palps. They are rounded and bear certain setæ on them. When in motion they are shot up and pulled down between the mandibles and the labium or fused second maxillæ; sometimes both are moved forward at once, sometimes they move alternately (Pl. XXXVII. fig. 7).

V. The second pair of maxillæ.—These have fused together and form a labium of a very simple kind. There is a median plate or mentum in which we found no transverse furrow. This plate bears anteriorly a pair of one-jointed processes ending in a few short stiff bristles. These are called by Grosse the paraglossæ, but, as there are a pair of minute one-jointed processes internal to these, it may be that they represent the palps. Whichever they are, they are very mobile and are constantly being divaricated into a position at right angles to the normal and then suddenly brought back again. They are obviously of use in bringing food to the mouth. The more median processes as well as the palps bear hairs. They are figured on Pls. XXXVI. & XXXVII. figs. 5 & 7.

A median structure which we think may represent the hypopharynx is the lyriform organ, or the "œsophageal sclerite" of Kellogg. This median piece is strongly chitinized, deep brown in colour, and consequently conspicuous; it seems to lie about in the same level with the first maxillæ, except when they are

* Zeitschr. wiss. Zool. xlii. 1885, p. 537.

protruded, when it lies behind them. A muscle on each side of the œsophagus runs from the anterior angle of the sclerite to the dorsal side of the head and brings about the movement of the organ. Kellogg has described in certain species a pair of oval glands which lie ventral to the sclerite and the ducts of which unite and open by a common duct into the median groove of the thickening. These glands are very conspicuous in *Goniodes*, and are shown in several of our figures. Their function is unknown. Their ducts are cross-barred like a trachea. The whole sclerite is conspicuous and shines through as a somewhat V- or U-shaped dark area, visible from above. As Kellogg points out, a similar apparatus exists in the Psocidæ (Pls. XXXV., XXXVI., & XXXVII. figs. 3, 5, & 7). Two salivary glands on each side of the œsophagus have been described in many genera of Mallophaga. The ducts of all four unite and open into the pharynx by a common duct.

The second maxillæ are so minute and feeble that we found it impossible to dissect them out even from macerated specimens.

VI. The prothoracic legs.—These pair of appendages are turned forward and their ends normally lie underneath the mouth. They doubtless take some part in feeding. Their inner ends are approximated, so that the sternum here is but little more than a line. Snodgrass* records that the prothoracic legs do not move synchronously with either of the others or with each other. One often moves backward as the other moves forward, and he holds that they serve to guide the body. He thinks they serve to pull the body up the feather, the prothoracic legs pulling whilst the other legs push, like a man climbing a rope.

VII. The mesothoracic legs.—These are larger than the preceding and are directed backwards; their bases are further apart. The details are shown in Pl. XXXIX. fig. 10. All the legs end in claws and bear a well-marked pulvillus.

VIII. The metathoracic legs.—These are still larger and, like the preceding, are directed backwards; the sternum between their bases is rather wider. The right and left mesothoracic legs move forward simultaneously and backward simultaneously, and so do the right and left metathoracic legs; but when the mesothoracic legs move forward the metathoracic legs move backwards, and *vice versa*.

In their general structure there is little beyond size in which the legs differ. Each consists of a coxa firmly applied to the ventral surface of the thorax; it is a broad, short piece, wide distally. The second article is a small trochanter which joins the hinder end of the wide coxa and seems to be almost part of the femur, but there is a marked thinning of the cuticle between it and the femur and a clear joint.

The femur with the trochanter and the next article or tibia

* *Loc. cit.* p. 152.

are of about equal length, but the tibia is not so stout; distally it bears a pair of stout bristles, hardly movable, against which the tarsal claws work. There are other bristles on the tibia, and numerous hairs on all the articles. The tibia bears a single-jointed tarsus which carries a pair of very mobile claws. These claws are constantly being depressed, usually one at a time, and rub against the tibial bristles. The tarsus also carries numerous knobs, and between the base of the claws a pulvillus may be seen; this in some cases is retracted.

The female has no external organs of reproduction, but on the seventh segment of the male there are situated ventrally a couple of complicated gonapophyses which presumably are modified abdominal appendages. These are figured on Pl. XXXVIII. fig. 9, which gives an adequate idea of their complexity.

Respiratory System.

The tracheal system of *Goniodes* opens on the exterior by seven pairs of stigmata. There may possibly have been more, but we could not detect them. The most anterior is the largest; it is situated close behind the first pair of legs and is very difficult to see. Snodgrass * has described one in a similar position in *Menopon titan*. From it a trachea passes inwards and gives off a twig to the second leg. Further on it divides, one stout branch running anteriorly into the head, where it divides into two, each splitting up into innumerable small branchlets supplying the organs in the head. From the main trachea the second branch passes backward, giving off a twig to the third pair of legs, and then runs backward through the abdomen as a main longitudinal trunk (Pl. XXXIX. fig. 11).

The abdominal stigmata are twelve in number, there being a pair on the second to the seventh segment, both included. They lie on little eminences like a tee in a teeing-ground, situated about one-sixth of the body breadth from the edge, and from each is given off a short trachea which soon splits into two branches. Of these the posterior splits up into innumerable fine twigs, which supply the various organs of the segment, and the anterior runs almost straight into the longitudinal trunk, thus placing the system connected with one stigma in communication with all the others on the same sides of the body. By this means, if one stigma be blocked the organs it supplies are not deprived of air, but receive it from another system. The smaller tubes on each side pass across the middle line and seem to place the right and left systems in communication. In *Menopon titan*, according to Snodgrass, the right and left systems communicate by means of a large transverse trunk in the fourth abdominal segment.

The spiral thickenings are well marked.

* *Loc. cit.*

The Alimentary Canal.

Grosse has described just within the mouth a dorsal and a ventral piece of a "schlundskelet." Unless the lyriform organ, or "oesophageal sclerite," represents the ventral piece, this structure is not evident except in sections.

The oesophagus is a simple tube with muscular walls which traverses the posterior part of the head and the thorax (Pl. XL. fig. 12). Soon after it reaches the abdomen it gives off a blind pouch or crop, which is always choked with feathers and forms the conspicuous black patch which shines through the wall of the abdomen. The walls are very muscular, both longitudinal and circular muscle-fibres being conspicuous. It usually lies near the middle line, but slightly obliquely, and pointing posteriorly to the right. Behind the point where the crop is given off the stomach or chylic ventricle passes backward, lying to the right of the crop. At the posterior end of this the four Malpighian tubules arise, and then there follows a short intestine in which usually masses of undigested feather-fragments are to be seen. The intestine is short and ends in a ring of six almost spherical (? glandular) bodies (Pl. XL. fig. 12). Each of these seems to consist of a single gigantic cell, and the whole is very richly supplied with tracheæ. These bodies closely resemble similar structures found in the rectum of many Diptera, *e. g.*, the blow-fly and the mosquito. Behind them there is a short rectum, which ends in an anus situated beneath the terminal plate. Numerous muscles run from the body-walls of the last two segments to be inserted into the rectum and doubtless act as divaricators.

The food consists of feather-barbules; a sample of it taken from the crop is shown in Pl. XL. fig. 13.

The Excretory System.

This system consists of (a) the Malpighian tubules, and (b) the Fat-body, in which nitrogenous waste matter is often stored away. The Malpighian vessels are four in number; they arise at the anterior end of the intestine, and near the base each swells into an oval vesicle (Pl. XL. fig. 12). The tubules are long, as long almost as the body, and are coiled away amongst the viscera.

The fat-body is very definitely arranged, there being paired pouches of it at the sides of each segment (Pl. XLI. fig. 16). In the cavity of these pouches are five collections of oval structures, which may be the five pairs of ovarian tubules, showing the ova, but somewhat similar structures occur, in equal numbers, in the male abdomen.

Nervous System.

We have not made a detailed examination of the nervous system, but may remark that it consists of a brain and a large infra-oesophageal ganglion in the head and of three ganglia in the thoracic segments. The last of these is the largest, and it supplies nerves to the organs of the abdomen.

Circulatory System.

This, again, we have not examined, but Wedl* and Kramer† have seen and described the hearts of several species. They seem to conform to the usual insect type, but the number of chambers is small, Wedl says only one in *Menopon pallidum*, situated in the last but one abdominal segment.

Reproductive Organs.

We have not investigated this system of organs in any detail, but it may be mentioned that in the Ischnocera, the subdivision of the Mallophaga to which *Goniodes* and *Nirmus* belong, there are four testes, the two on each side being united by a common vas deferens, which leads into a vesicula seminalis, which, though bilobed, is usually unpaired; from this an ejaculatory duct leads to a retractile penis. The extreme complexity of the external male organs is shown in fig. 9, Pl. XXXVIII. Morphologically there is an invagination of the body-wall of the last abdominal segment to form the genital cavity, and the various plates and bars which are seen in the drawing are chitinous thickenings in the walls of the invagination. In the centre of the genital cavity lies the penis, which is strengthened by chitinous rods and bars, and is capable of being protruded and retracted by a complicated system of muscles. In the male the anus has been involved in the invagination and comes to open dorsally into the genital cavity. This is not the case in the female, where the invagination is not close to the posterior end, but is formed by an invagination of the eighth abdominal segment. The vagina opens anteriorly and dorsally into this chamber, and passes into a long coiled oviduct which splits into two collecting-ducts, and these terminate in five ovaries on each side of the body. The ovaries dwindle out anteriorly, and their thread-like forward ends unite into a common termination.

An excellent comparative account of the reproductive organs of the group is given in Snodgrass's already-mentioned paper, and Gross‡ has written an account of the histology of the ovary, which he finds strikingly like that of the Pediculidæ.

* SB. Ak. Wien, xvii.

† Zeitschr. wiss. Zool. xix. 1869, p. 452.

‡ Zool. Jahrb. Anat. xxii. 1905, p. 347.

The Eggs.

The eggs are very beautiful objects; in badly infested grouse they may be numerous, but as a rule they were none too easy to find. Usually they occur in small groups attached to the base of the after-plume and between it and the shaft of the plume. The specimen figured was on one of the feathers from the flank.

The eggs are elongated, some three to four times as long as they are broad. They are fixed by some adhesive secretion at the end corresponding to the posterior end of the contained embryo. At the other end is a well-marked cap or operculum which always points to the free end of the feather. The beauty of the reticulated egg-case is shown best in the genus *Menopon*, and we figure one, which we take to be the egg of *Menopon pallescens* Nitzsch, found on the feathers of a partridge. Under the pressure of a cover-slip the egg-case gradually ruptured along a circular line below the well-marked thickened edge or rim of the operculum. The contained egg then began to emerge, carrying the operculum as a sort of cap, the resemblance to which was emphasised by the long process which stands out like a feather borne on the apex. The eggs of *Goniodes* show the reticulations less well, but they are well marked on the operculum, which bears a long tapering filament, longer than the egg itself. They also occur just below the opercular rim, but fade away towards the fixed end. The general appearance of the eggs in the after-plume is shown in Pl. XL. fig. 15. They were found on the 27th July, 1908, and they seem to be laid throughout the summer.

There is no metamorphosis, the young leaving the egg-shell as a miniature of their parents.

II.—*NIRMUS CAMERATUS* Nitzsch.

This insect seems to have been first named by Nitzsch* in the year 1818, but with no description. Indeed, the animal is mentioned under the subgenus *Nirmus*, but is called *Philopterus cameratus*. It is figured and described, and a bibliography is given, in Denny's 'Monographia Anoplurorum Britannie'† under the name of *Nirmus cameratus*. Denny found it on the Red Grouse, the Black Grouse, "and I expect also on the Ptarmigan." Grube describes it in Middendorff's 'Siberian Travels' as existing on *Lagopus albus* and *L. alpinus*, thus confirming Denny's surmise.

It is mentioned in Giebel's article‡ on the Halle Bird-lice, and described and figured in his great monograph 'Insecta

* Germar's 'Magazin der Entomologie,' Halle, iii. 1818, p. 291.

† London, 1842, p. 112.

‡ Zeitschr. ges. Naturwiss. xxviii. 1866, p. 370.

Epizoa.' Piaget, in his 'Les Pédiculines,' states his conviction, that *N. cameratus* is specifically identical with the *N. quadrulatus* of Nitzsch, from *Tetrao urogallus*, the Capercaillie. Kellogg in his Mallophaga ('Genera Insectorum') does not mention *N. cameratus* though he records *N. quadrulatus* from *T. urogallus*, *T. tetrix*, and *Lophophorus impeyanus*.

Nirmus is a more slender animal than *Goniodes*, and appears to be longer. It is rarer than the latter, though in the great majority of cases the two are found together. Most of what has been said above about *Goniodes* applies also to *Nirmus*, as their habits are very similar, except that *Nirmus* lives more on the skin and upon the base of the rachis of the feather than does *Goniodes*. It also seems to frequent the feathers under the wing, where *Goniodes* is seldom seen. Both species seem to wander all over the body; and though they seem rather more common upon the head, neck, and back, the old view that these biting-lice occur chiefly or exclusively on those parts of the body inaccessible to the beak was not borne out by our investigations (Pl. XLI. figs. 17 & 18).

The variation in size and in colour is very considerable. Dead specimens are not infrequently found, and these may be in some cases mistaken for cast skins. An average length is 3 mm., and an average width of the abdomen is 1.5 mm. The abdomen is the widest part. In no case did we find either *Goniodes* or *Nirmus* in the crop of the grouse, though, as we have just stated, they are fully exposed to being snapped up by the bird's beak if the bird cared to notice them. It is not known exactly how clean birds get infected: probably the Mallophaga simply crawl from one bird to another when the latter are contiguous, and the young birds are infected on the nest. There is evidence, however, that in some cases, probably rare ones, they cling to the grouse-ly and are by it transported to a new host.

In the summer of 1907 Mr. Fryer found some Mallophaga eggs. These were for the most part empty, but from one or two full ones he has succeeded in hatching out specimens of *Nirmus cameratus*. The eggs are white, and transparent when empty, just visible to the naked eye, 0.6 mm. in length, and about four times as long as they are broad. Each egg-case is beautifully reticulated, the areas between the reticulations being six-sided. At one end the egg has a cap which is pushed off when the young emerges. The eggs are laid between the barbules of the vanes or near the bases of the filo-plumes, and adhere to their supports by means of some sticky excretion (Pl. XLII. fig. 20).

The eggs appear to be laid throughout the summer; the first time we found them (some of them were empty) was on 2nd July, 1907, and we found others later in the season.

There is no metamorphosis; the young emerge from the egg-case as small miniatures of their parents. They seem to cast their skin several times, but the exact number of ecdyses is not known.

B. DIPTERA.—Flies.

(i.) Fam. Hippoboscidæ.

III.—*ORNITHOMYIA LAGOPODIS* Sharp.

Till recently it had been thought that the grouse-fly was the same species as the common bird-fly, *Ornithomyia avicularia* L.; but recently Mr. D. Sharp* has pointed out that it is a distinct species, which he has described, as follows, under the name of *O. lagopodis*:—It is “smaller than *O. avicularia*, and distinguished by its peculiar lurid blackish colour, without any trace of green even on its feet or legs; the rostrum is black, and the hairs of the body and appendages are shorter than in the better-known form; on each side of the thoracic pleuron, between the front and middle legs, there is a very large dark patch extending as far towards the middle as the base of the front coxa, and divided into two parts by an oblique pallid line. The head is considerably smaller and narrower than that of *O. avicularia*, and has beneath a very large area of smoky colour on each side. Mr. Collin has pointed out that the segments, or abscissæ, of the costa afford a good character; the relative lengths of the outer two being in *O. lagopodis* as 9–8, and in *O. avicularia* about 12 or $12\frac{1}{2}$ –8. The bristles on the scutellum are usually more numerous, as well as larger, in *O. avicularia*.” Recently a second species, *O. fringillina* Bezzi, has been separated off from the *O. avicularia*, so that we now have three species of *Ornithomyia* in this country, and probably more will be added as the group is further studied. Mr. Sharp thinks that the same species frequents the willow-grouse, *L. albus*, of Scandinavia.

The head and mouth-parts of this fly are very interesting. A ventral view shows, between the eyes, the short antennæ apparently of two joints, ending in four hairs, of which one is far longer than the others; other symmetrically arranged hairs are shown in Pl. XLIV. fig. 22. In the middle line is the proboscis; this consists of two lateral, movable, palp-like structures, each bearing hairs and terminating in a stout bristle. These structures are presumably the maxillary palps. Then there is a median very mobile structure, which is the sucking-tube; this moves in all planes, and may be protruded or withdrawn. Its mouth shows a somewhat plicated orifice, and behind it undoubtedly ends in a sucking pharynx. This median structure is probably homologous with the second maxillæ or the labium.

The feet of the grouse-fly are large but very beautiful. In Pl. XLIV. fig. 23, we show the outer surface of one of the feet, and the same figure shows part of the femur, the tibia, and the five joints of the tarsus, the fifth being by far the largest.

* Ent. Monthly Mag. II. ser. xviii. 1907, p. 58.

Fig. 24 shows the inner surface of the same, and on Pl. XLIII. will be found a coloured sketch of a foot seen obliquely. From these drawings, which have been prepared for me by Mr. Edwin Wilson of Cambridge, it will be seen that the large paired claws are double, and that whereas the distal limb of each claw is slender and very sharply pointed, the proximal limb is much stouter and ends bluntly. Between the claws is a median, feathered, process with hairs or bristles, and at the base of each double claw is a pulvillus covered with minute hairs. As fig. 24 shows, there are other processes for which I have no name. The arrangement of the hairs is faithfully given in the drawings.

We do not know the exact relations of the grouse-fly to the grouse. It is believed to suck its blood, and it will certainly bite human beings. For a time it seems to burrow amongst the feathers of the bird, and anyone handling grouse during the summer is likely to disturb a fly or two. They come buzzing out and are apt to crawl up one's sleeve by aid of the pair of great hooked claws on their feet. Altogether they have a sinister aspect, and to people who do not like flies they are very repellent. They occur freely in larders where freshly-killed grouse have been placed, and after a short time they leave their dead host and accumulate upon the windows.

The earliest month we have found the grouse-fly is in June, towards the end. The latest we have found up till the present time is September. Mrs. Duff Dunbar has taken them as late as October. Perhaps they are most plentiful in August.

The females seem to be commoner than the males, or, it may be, in August are more readily taken. Like other members of the Hippoboscidae, which includes the horse-fly, forest-fly, and sheep-tick, the grouse-fly does not lay eggs, but the ovaries produce one large ovum at a time, and this passes into a dilated oviduct which acts as a uterus, and here the egg develops. After attaining a certain stage of development, the larva surrounds itself with a pupa-skin and is extruded. The chitin covering the larva hardens and blackens with exposure to the air, and forms the so-called pupa-case; in fact, one may almost say the young are hatched as pupæ. At no time is the larva exposed, though there is a larval stage free in the uterus wrapped first in the egg-shell and then in the pupa-case.

When first deposited the pupæ are light in colour and the case has not hardened. Those dissected out from a fly are shorter and more squat than the mature pupæ found on the ground (compare *a* and *b* in fig. 25, Pl. XLIV.), and the symmetrical ridges and elevations are much less well marked (Pl. XLIV. fig. 25, *d* & *c*). The mature pupæ are shown from above, from the side, and from the micropylar end in Pl. XLIV. fig. 25, *c*, *e*, & *f*, highly magnified. Between them they show well the six elevated and cross-barred ridges which radiate from the micropyle to the angles of the hexagonal micropylar area.

The pupæ were found during August and September. They

appear to be deposited amongst the feathers and are easily detached from them. The few we have found either dropped on some paper over which we were handling some birds, or lay loose at the bottom of the cardboard boxes in which grouse travel. Probably they take some eight or nine months before they give rise to the imago, and the latter very likely disappear altogether from about October till June. Further research is needed to throw light on these questions.

Three specimens of *O. lagopodis*, all of them taken from one grouse, were themselves markedly infested with an ectoparasite, a species of mite. Here I refrain from quoting Dean Swift. The mite belongs to the genus *Canestrinia*, as my friend Mr. C. Warburton has kindly told me, and is probably a new species. The subfamily Canestriniæ are all parasitic upon insects, and are regarded as harmless. Our specimens existed in considerable numbers, clustered round the hinder end of the fly's abdomen on the ventral surface, with their proboscides plunged into its body. Many were laying eggs, and many cast-off cuticles were lying around. Eggs from which the larvæ had escaped presented a spindle-shaped outline; others contained ova in various stages of differentiation; others fully formed larvæ.

We have in no single case found a grouse-fly in the crop of a grouse, nor have we yet found any cestode larvæ or cysts in the bodies of the flies which we have cut into sections or dissected.

(ii.) Fam. Scatophagidæ=Scatomyzidæ.

IV.—*SCATOPHAGA STERCORARIA* L.

This fly cannot be looked upon as an ectoparasite of the grouse, but it lays its eggs in grouse-droppings, and its maggots live on and in these dejecta. The maggots must therefore constantly be in close contact with and possibly eating the ova of the tape-worms which exist in such vast numbers in the grouse-droppings; and here we thought it was a profitable object to investigate for the cysticercus or second stage of the cestode. It should be mentioned that the droppings consist of two parts: (1) the dejecta from the intestine strictly speaking, and (2) the more fluid dejecta from the cæca. The latter pass last and lie like a cap upon the former. The fly-maggots are only found in numbers in the "cæcal" part of the dropping. Mr. Fryer first found them commonly at Fort Augustus in April. In June they were not so common, owing perhaps to the rain which washed the cæcal part of the droppings away. We examined a large number of the larvæ both by squashing them and cutting them into sections, but we found no trace of infection; in fact, here, in this most likely place, we again drew a blank. No specimen of *S. stercoraria* or of its larvæ has been found in the crop. This fly, which, as

stated above, we believe to be *S. stercoraria*, may eventually turn out to be a local variety.

The larva of the fly has the usual maggot-like shape, tapering from behind forward towards the mouth. Counting what appears to be the cephalic segment—but which in reality probably represents more than one segment, and which is thus conveniently called the “pseudo-cephalon”^{*}—as one segment, there are thirteen in all, the usual number for Dipterous larvæ (Pl. XLV. fig. 26).

The cuticle is thin, the maggots are white. They bear numerous small spines which are especially conspicuous in a ring around the anterior end of each segment. These rings emphasize the segmentation of the larva.

The “pseudo-cephalon” is pointed, and varies in outline according to how much of the mouth and its sclerites are protruded or not. These sclerites are the most conspicuous structures in the larvæ; jet-black, they stand out against the white tissues of the maggot. There is a pair of hooks which apparently correspond with the single median mandibular sclerite of *Musca domestica*†. At the base of each of these is a dentate sclerite, and behind the mandibular sclerite articulates with the hypostomal sclerites. These latter are irregular longitudinal bars connected by a slight transverse plate on the ventral side. In *M. domestica* the salivary glands open into the pharynx just in front of this transverse piece. Posteriorly the hypostomal sclerites are very closely articulated, or perhaps even fused with the large lateral pharyngeal sclerite. This consists of a ventral plate, continuous with two lateral plates which are deeply notched, and in the house-fly the nerves and tracheæ which supply the pharynx enter through this notch. The two lateral plates are united anteriorly by a dorsal cross-piece. The whole of these sclerites are being continually pushed forward and retracted by a complicated series of muscles which have been carefully described in the case of *M. domestica* by Dr. C. Gordon Hewitt (Pl. XLV. fig. 27).

The mouth is bordered by tumid lips, above which the hook-like mandibular sclerites are pulled and pushed in and out. Dorsal to these again are two elevations which each bear two sensory papillæ; these correspond with the sensory tubercles of *M. domestica*, though the latter are not borne on an elevation.

The anus opens on the truncated thirteenth segment, well forward on the ventral surface; around it, symmetrically placed, are four anal papillæ, which assist in the movements of the maggot (Pl. XLVI. figs. 31 & 32).

The tracheal system opens on the flattened posterior end, about the centre. Ventral to the stigmata there are two or three pairs of low papillæ. Each stigma leads into a trachea, which almost immediately splits into a visceral branch (Pl. XLV. fig. 26) which bends down into the viscera and extends a little way in

^{*} Henneguy, L. F., ‘Les Insectes,’ Paris, 1904.

† C. Gordon Hewitt, Quart. J. Micr. Sci. lii. 1908, p. 495.

front of the middle of the body. Before splitting in *M. domestica* the right and left main trunks are put into communication by a transverse trunk; if this exists in *S. stercoraria* it escaped our notice. The lateral trunks give off in each segment a dorsal and ventral twig. Anteriorly, in what appears to be the third segment (it is described as the fourth in the house-fly), there is a transverse commissure by means of which the right and left trunks are put into communication. In front two small twigs are given off from this transverse commissure which run to the pharynx. The main trunk is continued forward, and at the second segment (the third in the house-fly) it ends in a process like a little rake (Pl. XLV. figs. 26 & 27). This is due to the splitting up of the trachea into eight or nine little twigs, all in the same plane and all ending in a knob. The whole is called the anterior spiracle, and can be protruded from the body and retracted. Hewitt states that in the house-fly each of these knobs opens to the surface by a very minute pore.

C. SIPHONAPTERA.—Fleas.

(i.) Fam. Pulicidæ.

V.—*CERATOPHYLLUS GALLINULÆ* Dale*.

Synonym: *Ceratophyllus* (*Trichopsylla*) *newsteadi* † Rothschild.

I am indebted to my friend Mr. N. C. Rothschild for identifying this flea, which is here recorded for the first time from the grouse. It is a well-known bird-flea, having been found in the nest of the hawfinch, *Coccothraustes vulgaris*, in that of the dipper, *Cinclus aquaticus*, in that of the blackbird, *Turdus merula*, the moor-hen, *Gallinula chloropus* L., and others. In the thousands of grouse which have passed through our hands we have found but one or two specimens of this flea, all in 1906, and we have never found a single specimen in the crop. Hence, although the dog-flea, *Pulex serraticeps* P. Gerv., is said to be the intermediate host of the dog tape-worm, *Dipylidium caninum*, it seems hardly possible that the *C. gallinulæ* could play any part in the life-history of the grouse tape-worms. In identifying a flea almost every hair tells, and as *C. gallinulæ* has not been accurately figured before, I take this opportunity of figuring it in both sexes.

VI.—*CERATOPHYLLUS GAREI* Rothschild.

This second species of flea was found in a grouse in 1907; we only took one or two specimens. It is recorded by Evans‡ from the nest of the water-vole, of the lapwing, *Vanellus vanellus*, and of the ring-dove, *Columba palumbus*. Rothschild § has found it

* N. C. Rothschild, Ent. Monthly Mag. II. ser. xiv. 1903, p. 145.

† Ent. Rec. xiii. 1901, p. 284.

‡ Ann. Scott. Nat. Hist. 1906, p. 163.

§ Ent. Monthly Mag. II. ser. xiii. 1902, p. 225.

in the nest of a water-hen, *Gallinula chloropus*, and he records it as having been taken from *Mustela erminea*, *M. vulgaris*, *Sorex vulgaris*, *Microtus glareolus* and *M. amphibius*, and from hedge-clippings.

ARACHNIDA.

ACARINA.—Mites and Ticks.

(i.) Fam. Ixodidæ.—Ticks.

VII.—*IXODES RICINUS* (L.).

This is one of the commonest and one of the oldest-known ticks of Europe. In the British Isles it usually occurs on hunting-dogs and is sometimes called the “dog-tick”; the adult stage is especially frequent on sheep, goats, and oxen, less common on horses, dogs, and men. Mr. William Evans*, of Morningside Park, Edinburgh, tells me that he has not found this species on dogs—in his district the “dog-tick” being *Ixodes hexagonus* Leach, var. *inchoatus* Neum. On the other hand, the larvæ and the nymphs are common enough on birds, lizards, and small mammals—in fact, on animals which live among and brush against grass or heather. It is only in the nymph and larva state that we found these ticks on the grouse. On each of the infested birds the specimens were fixed on the chin or around the eyelids—in fact, in such positions as the grouse cannot reach with its beak. In parts of Ross-shire, especially in certain woods, these ticks swarm in enormous numbers, and the keepers assure us that they kill large numbers of young blackgame. Hence there is nothing remarkable in finding this species from time to time on the grouse, where its presence must be regarded as accidental. The larval stages emerge from the eggs and probably crawl on to the heather, and thence on to the grouse or other animals which come in contact with the vegetation. We have found both larvæ and nymphs amongst the feathers, but in small quantities and on rare occasions. We have never found it in the crop, and it can hardly play any part in infecting the bird with tapeworms.

Ixodes ricinus, or the “castor-bean tick,” as it is called in America, is common in many parts of the world. It is reported from sheep, goats, cattle, horses, deer, dogs, cats, foxes, ferrets, hedgehogs, hares, rabbits, bats, birds, and man. This tick occurs most frequently during the spring and early summer, but can be found in lesser numbers up till September and October, possibly later.

Severe epizootics amongst fowl of spirillosis and of another obscure but very often fatal disease have been described by

* Ann. Scott. Nat. Hist. 1907, p. 35.

Balfour* in the Sudan. The spirochaete, probably *Spirochaeta gallinarum*, which causes the first-named disease is transferred from one fowl to another by a tick, *Argas persicus*. The second, and as yet rather obscure, disease is recognised by the natives and by them associated with the presence of the *Argas*. We have found no traces of such disease in grouse, and the recorded number of ticks taken in the grouse is, except locally, so small that they can hardly play any part in grouse-disease.

(ii.) Fam. Tyroglyphidæ.

VIII.—*ALEUROBIUS FARINÆ* (de Geer).

Synonym: *Tyroglyphus farinæ* Gerv.

Mr. C. Warburton has kindly identified for us a small mite which was found in considerable numbers on several birds and at varying times of the year. Whilst very common at Easter time, they were less abundant in July. *Aleurobius farinæ*, sometimes known as the flour-mite, occurs in great numbers on all sorts of organic material—grain, straw, hay, tobacco, flour, cheese, dead bodies, etc., etc. At times workmen handling corn, cats, horses, etc., have suffered much cutaneous irritation and eruption from the attacks of this mite. There seems no doubt as to the species of this mite, but the authorities on these animals express surprise that they should occur so commonly on the grouse. Our specimens, some of which were taken on freshly killed grouse, contained some red substance in the stomach, probably some blood from the bird. There seems at present little reason to incriminate this mite as the carrier of the tape-worm cyst. They were, however, found by Mr. Fryer on a large majority of birds which were especially searched with the view of finding mites.

(iii.) Fam. Gamasidæ.

IX.—*GAMASUS COLEOPTRATORUM* (L.).

We have also taken this common, fawn-coloured mite off the feathers of a grouse. It is usually found on beetles, but winters under stones, and it is said to soon die if removed from the beetle or from under the stone where they hide, unless they are kept moist. The beetles they favour are usually burrowers in the damp ground or under cow-dung. They probably passed on to the grouse from under stones.

* Brit. Med. Journ., 9th November 1907, No. 2445, p. 1330.

GENERAL DISCUSSION ON THE RELATIONS OF ECTOPARASITES
TO THE ENDOPARASITES OF THE GROUSE.

We have in the alimentary canal three species of tape-worm, two of the genus *Davainea* and one of the genus *Hymenolepis*. We know that tape-worms, with perhaps the exception of one species, pass through two distinct and different animals known as hosts. In one animal it lives as an adult, in the other as a larva. The larval host is always, sooner or later, eaten by the host of the adult, and then the larval tape-worm or cyst grows into the adult tape-worm. It was with the hope of discovering the second or larval host of the grouse cestodes that we began a laborious research on the insects and arachnids which infest the grouse. Unfortunately, little or nothing is known about the life-history of any species of either *Davainea* or *Hymenolepis*. The larval or cystic stages of the former have in some few cases been said to occur in insects and in molluscs; the larva of the latter is thought to live in an insect or a myriapod, or perhaps even more likely some "water-flea" or other fresh-water crustacean.

With regard to these possible second hosts. We have never found a myriapod in the crop of a grouse, and so far we have not found any crustacea—though it must not be forgotten that these are probably so small as to escape notice. We have found one species of slug in the crop of a Staffordshire grouse, which Mr. W. E. Collinge has kindly identified for us as *Arion empiricorum* Férussac, a species of slug which is common on the Staffordshire grouse-moors. He tells me that the slug undoubtedly belongs to the genus *Arion*, and almost certainly to Férussac's species *A. empiricorum*, a name J. W. Taylor, in his 'Monograph of Land and Fresh-water Mollusca of the British Isles'*, includes among the synonyms of *Arion ater* (L.). The well-known difficulty of identifying slugs which have been preserved and which have lost their colour accounts for the slight doubt that exists. *Arion empiricorum* is very voracious and practically omnivorous; it will eat almost anything, especially decaying animal and vegetable matter, fungi, paper, weak and injured worms and slugs, and—what is interesting from the point of view of the grouse tape-worms and round-worms—it devours the dejecta of other animals. It prefers the shady places in moors and fields, and emerges into the open only at dusk or when the day is cloudy or overcast. The following parasites which may give rise to adult forms in the grouse have been found in *A. empiricorum* :—

TREMATODA (Flukes) :

- (1) *Cercariacum limacis* Duj.†
- (2) *Cercaria trigonocerca* Dies.‡

* Leeds, part xi. p. 167.

† Dujardin, Hist. nat. des Helm. p. 472.

‡ Leuckart, Paras. d. Menschen, 2nd edit. ii. p. 86.

CESTODA (Tape-worms):

- (1) *Cysticercus arionis* v. Sieb.*
- (2) *Cysticercus teniae arionis* v. Sieb.†

NEMATODA (Round-worms):

- (1) *Leptodera angiostrongylus* Duj.‡
- (2) *Leptodera appendiculata* Schneider §.
- (3) *Nematodum limacis atra* v. Sieb. ||
- (4) *Pelodytes hermaphroditus*, Schneider ¶.

We have cut one of these slugs into sections, and have sought diligently through them for cysts of tape-worms, but have found none. This absence of infection, combined with the great rarity of the slug in the grouse's crop, seems to show that *A. empiricorum* is not the second or larval host of the grouse cestodes.

Dr. Wilson and Mr. Fryer "tow-netted" some of the moor streams in April 1907, and found a certain number of the nauplius larva, probably of *Cyclops*, and a certain but small number of adult *Cyclops*. The numbers were, however, meagre, and tow-nettings later in the summer yielded an even more unsatisfactory "bag." None of the crustacea when examined microscopically showed any cysts, and as they were few in number and quite cyst-less, it seems improbable that the source of the tape-worm infection lies here.

Mr. D. J. Scourfield, who kindly looked through some of these tow-nettings, tells me he found the following species of Entomostraca:—

CLADOCERA.

- Chydorus sphericus* O. F. M., the most abundant form.
Alonella nana (Baird, Norman & Brady), frequent.
Alonella excisa (Fisch.), frequent.
Acantholeberis curvirostris (O. F. M.), a fair number, with some cast ephippia.

COPEPODA.

- Cyclops nanus* Sars, a few.
Cyclops languidus Sars, a single specimen only seen.
Cyclops vernalis Fisch., again only one specimen was seen.

I subjoin three more lists of tow-netted freshwater Entomostraca from three different lochs. These were collected and identified by Mr. Wm. Evans, who has kindly put them at my disposal, and they clearly indicate the sort of surface fauna which may be obtained from the lochs on the Scotch moors in early autumn.

* Von Siebold, Zeitschr. wiss. Zool. ii. 1850, p. 202.

† Krabbe, Nye Bidrag, p. 5; and Villot, Ann. Sci. nat. 6th ser. xv. 1883.

‡ Schneider's Monograph, p. 157.

§ Schneider's Monograph, p. 159.

|| Schweiz. Zeitschr. Med. 1848.

¶ Zeitschr. wiss. Zool. x. p. 176.

LIST I.

From Loch Rusky, a moorland loch a few miles from Callander, which was tow-netted on the 16th September, 1906.

CLADOCERA.

- Simosa vitula* (O. F. M.).
- Eurycercus lamellatus* (O. F. M.).
- Alonopsis elongata* G. O. Sars.
- Alona affinis* Leydig.
- Chydorus sphaericus* (O. F. M.).

OSTRACODA.

- Cyclocypris globosa* (G. O. Sars).
- Pionocypris vidua* (O. F. M.).
- Notodromus monacha* (O. F. M.)
- Candona candida* (O. F. M.).

COPEPODA.

- Moraria brevipes* (G. O. Sars).
- Cyclops viridis* (Jurine).
- Cyclops annulicornis* Koch.
- Cyclops serrulatus* Fischer.

LIST II.

From Peat-pools on grouse-moors on Ben Ledi, in South-west Perthshire, Sept. 1908.

CLADOCERA.

- Chydorus sphaericus* (O. F. M.), very abundant.

OSTRACODA.

- Herpetocypris tumefacta* (B. & R.).
- Cypridopsis villosa* (Jur.).
- Potamocypris fulva* (Brady).
- Candona candida* (O. F. M.).

COPEPODA.

- Attheyella zschokkei* (Schm.).
- Attheyella cuspidata* (Schm.).
- Cyclops vernalis* Fisch.

LIST III.

From Loch-a-Chroin, north of Callander.

CLADOCERA.

- Bosmina longirostris* (O. F. M.).
- Acroperus harpae* Baird.
- Alonopsis elongata* (G. O. Sars).
- Alona quadrangularis* (O. F. M.).
- Alonella excisa* (Fisch.)
- Chydorus sphaericus* (O. F. M.).

OSTRACODA.

Cyclocypris serena (Koch).

COPEPODA.

Diaptomus gracilis (G. O. Sars).

Cyclops viridis (Jur.).

Cyclops serrulatus Fisch.

Also the common freshwater Amphipod, *Gammarus pulex* (De Geer).

A complete list, so far as was known at that time, of the Entomostraca of the Highlands and of the Lowlands could be extracted from the very useful Synopses published by Scourfield in the Journal of the Quekett Microscopical Club during the years 1903 and 1904.

In none of the species examined have we yet succeeded in finding any cysts.

We have thus with some degree of probability shut out as the second or larval host of the tape-worms—at any rate for the present—the ectoparasites of the grouse, the myriapoda and the slugs or snails, and the fresh-water crustacea, and this on the grounds (1) that on examination none of them reveals a cyst, and (2) that these animals are either not eaten by the bird, or so rarely eaten and in quantities so small as to render it highly improbable that any of these invertebrates could account for the almost constant presence of the cestodes in large numbers in the grouse.

Two rather striking facts seem to point to the normal insect food of the grouse, which it picks up on the moor, as the more probable source of the tape-worms. One is, that two of the artificially reared grouse at Frimley, which died during the early autumn of 1907, were carefully searched for tape-worms; but neither *Davainea* nor *Hymenolepis* was found. The second fact is, that the young grouse often contain fully grown *Davainea* before they are three weeks old. They must certainly have swallowed the second host when very young, perhaps even the day they were hatched, or the worm would not have had time to grow. Hence our best chance of finding this second host is to examine the crop-contents of the very young birds, and to do this we must have a moor at our disposal, and leave to kill as many young birds as we may want.

I have been assured over and over again by sportsmen and gamekeepers that the grouse eats no insects, but this is far from the truth.

Although the observations on the animal food of grouse are still incomplete, enough has been done to show that it is fairly abundant and very varied.*

From the crop of a single bird I have taken six larvæ of

* A fuller report on the insects found in the grouse-crop is given by Mr. J. C. F. Fryer in the Interim Report of the Grouse Disease Inquiry, published in August 1908. The following two paragraphs relate to some observations of my own, made in 1905 and 1906.

Tenthredinidæ (saw-flies), eight caterpillars of a Geometrid moth, one caterpillar of a smaller moth, two small Tineid moths, a number of immature Homopterous insects resembling the "frog" or "cuckoo-spit," a fly, possibly a *Leptis*, two specimens of the family Aphidæ (plant-lice), one small spider, and the remains of four specimens of the slug *Arion empiricorum* Fér. The gizzard of the same grouse contained, in a more broken up condition and consequently more difficult to identify, two or three dozen larvæ of saw-flies and moths, some young Homopterous insects, and the pupæ of two Muscid flies.

The segments of the grouse tape-worms containing the ripe eggs pass away with its dejecta and get on the ground or on to the heather and other plants, or into water. The eggs of the two species of *Davainea* are believed to develop into the cestode larva inside the body of an insect or a land mollusc. They are excessively minute, and lying as they do in millions on the heather, may be readily consumed by the leaf-eating caterpillars and other insect larvæ which live on the moors. Doubtless many are eaten by the grouse themselves, but they are digested and come to nothing. As we have said above, a tape-worm must have a second or intermediate host, and its larval stage must be passed inside an animal quite distinct from that which harbours the adult worm. To get at and eat the eggs seems to me an easier matter for caterpillars and other insect larvæ or for slugs than it is for the ectoparasites, which as a rule are not very likely to come across the dejecta of their host. For this reason, in looking for the larval tape-worm, we are now searching the insect larvæ and the slugs eaten so eagerly by the grouse. A common food of grouse is the head of certain species of rush. *Juncus articulatus* v. *lamprocarpus*, *J. squarrosus*, and *J. effusus* v. *conglomeratus* are all frequently eaten. There is a very minute moth the larvæ of which live in curious, white, papery cases inserted into each twig of the rush-head which they eat. When the rush is in its turn eaten by the grouse, the larvæ of the moth pass into the alimentary canal of the bird and are there digested. It has not been possible to finally determine the species of the moth; but I think it is *Coleophora cæspitiella**, for this species frequents many species of rush; whereas the *C. glaucicolella*, the other inland species, is most partial to *Juncus glaucus*. The former is usually fully out by the middle of June and lingers on till the middle of July; the last-named moth issues about the middle of July, and flies for four weeks. The case is whitish, semi-transparent, and with brown specks; it is found when the larva is no longer young, but not at any very fixed time. At first its outer end is closed. The larva often leaves the case, burrowing into the rush-head for food, and at times fails to refind it. Before pupating, the outer or anal end of the case is opened and the case strengthened by a glandular excretion. These larvæ should be searched for cysts.

* J. H. Wood, Ent. Mag. II. Ser. iii. (xxviii.) 1892.

EXPLANATION OF THE PLATES.

LIST OF ABBREVIATIONS.

a., anus.	mi., micropyle.
ant., antennæ.	m.s., mandibular sclerite.
a.p., chitinous rod supporting upper movable lip.	m.t., Malpighian tubules.
a.s., anterior spiracle.	1 max. & 1 mx., 1st maxilla.
c., coxa.	2 max. & 2 mx., 2nd maxilla.
cr. in fig. 12, & c. in fig. 16, crop.	mx.p., maxillary palp.
dg. in fig. 27 & ds. in fig. 28, dental sclerite.	œ., œsophagus.
dg. & d.gl., ducts of oval glands.	ov., ovary.
e., eye.	p. & ped., pulvillus.
emp., empodium.	prob., proboscis.
f., femur.	p.s., posterior spiracle.
f.b., fat-bodies.	ph.s., pharyngeal sclerite.
gl. & glds., oval gland.	r.gld., rectal glands.
h.l., "moustache" lip.	sp., spines.
h.s., hypostomal sclerite.	st. in fig. 9, crop; in figs. 29 & 30, st., sensory papillæ.
int., intestine.	sti., stigma or spiracle.
1st lg., 1st leg.	sto., stomach.
lu., upper lip.	t.c., transverse commissure.
lyr., lyriform organ.	ta., tarsus.
m., mouth.	ti., tibia.
m.a., micropylar area.	tr., trochanter.
mb., rectum.	u.l., upper lip.
md., mandible.	v.t., visceral trachea.

PLATE XXXV.

- Fig. 1. *Goniodes tetraonis* Denny, male seen from above. The legs are shown on the left side only. The forked character of the antennæ, the upper lip and the lyriform organ are well shown in the head and the male genital plates in the abdomen.
2. *Goniodes tetraonis* Denny, female seen from above. Note the different shape of the head and of the outline of the body. The legs are not shown.
3. The same seen from below, showing the upper lip, the mandibles, the lyriform organ, and the legs.

PLATE XXXVI.

- Fig. 4. Ventral view of head of male *G. tetraonis*, showing the forked antennæ, the mandibles, the pores in the chitin under the hairs, the muscles running to the upper lip, the eyes, the lyriform organ, and the ducts of the oval gland.
5. View of mouth-parts showing the "upper lip" *u.l.*, the moustache lip *h.l.*, the mandibles *md.*, the first maxillæ *1 max.*, the second maxillæ *2 max.*, the ducts of paired glands *d.gl.* and the lyriform organ *lyr.*, and the chitinous bar supporting the upper lip *a.p.*; *glds.*, the oval gland.

PLATE XXXVII.

- Fig. 6. View of the ventral surface of right mandible showing the complex nature of its articulation.
7. View of the 1st and 2nd maxillæ and of the mouth, the mandibles having been removed. The glands with their paired ducts uniting in the middle line to open by a median duct into the pharynx, in the centre of the lyriform sclerite. *m.* mouth.

PLATE XXXVIII.

- Fig. 8. View of the glands and the lyriform organ, showing the opening of the duct.
9. Ventral view of the complex, male, external reproductive apparatus, formed by various sclerites in the wall of the invaginated genital pouch. The posterior angle of the crop *st.* is shown.

PLATE XXXIX.

- Fig. 10. A ventral view of the right mesothoracic leg, showing the joints, claws, and *p.* the pulvillus, *c.* coxa, *f.* femur, *ta.* tarsus, *ti.* tibia, *tr.* trochanter.
11. View of the tracheal system of a female, showing the stigmata, *sti.*

PLATE XL.

- Fig. 12. Alimentary canal of *G. tetraonis* dissected out: *oe.* oesophagus, *cr.* crop, *sto.* stomach, *m.t.* Malpighian tubules, *mb.* intestine, *r.gld.* rectal glands.
 13. Some of the crop-contents of *G. tetraonis*, pressed out. It consists of feathers in various stages of disintegration.
 14. Egg of *Menopon pallescens* Nitzsch. Under pressure the operculum has come off and the ovum is squeezing its way out.
 15. Four eggs of *Goniodes tetraonis*, attached to the base of an after-plume, between it and the shaft of the plume of a feather from the flank. In one of them the operculum has fallen off.

PLATE XLI.

- Fig. 16. Optical section of abdomen of *G. tetraonis*, showing *a.* anus, *c.* crop, *f.b.* fat-bodies, *int.* intestine, *r.glds.* rectal glands, *ov.* ovary.
 17. *Nirmus cameratus* Nitzsch. Dorsal view of female.
 18. Ventral view of the same.

PLATE XLII.

- Fig. 19. Ventral view of head of *Nirmus cameratus*, showing mouth-parts, antennæ, eyes, position of anterior legs.
 20. Eggs of *Nirmus cameratus* on the feathers of a young grouse approximately three weeks old. A. Very slightly magnified; three eggs on one of the wing-coverts. B. Magnified about eight times on a downy plume. C. Very highly magnified to show the reticulations.

PLATE XLIII.

- Fig. 21. *Ornithomyia lagopodis* Sharp. A. dorsal view, B. ventral view, C. dorso-lateral view of foot.

PLATE XLIV.

- Fig. 22. A ventral view of the anterior edge of the head of *O. lagopodis* and the mouth-parts. *Ant.* antennæ, *e.* eyes, *max.* maxillary palp, *prob.* proboscis. A still more enlarged view of the orifice of the proboscis is shown to the right.
 23. A figure of part of the femur, *f.*; the tibia, *ti.*, the tarsus, *ta.*, and the foot of *O. lagopodis*.
 24. The same, more highly magnified, from the inner or under surface. *emp.* empodium, *ped.* pulvillus.
 25. Five sketches of the pupa of *O. lagopodis*. A. Life-size figure of the mature pupa; B. the same of an immature pupa dissected out of a fly; C. mature pupa-case magnified and seen from the micropyle end; D. a similar view of the immature pupa; E. mature pupa-case seen from above; F. the same seen from the side. *m.* micropyle, *m.a.* micropylar area.

PLATE XLV.

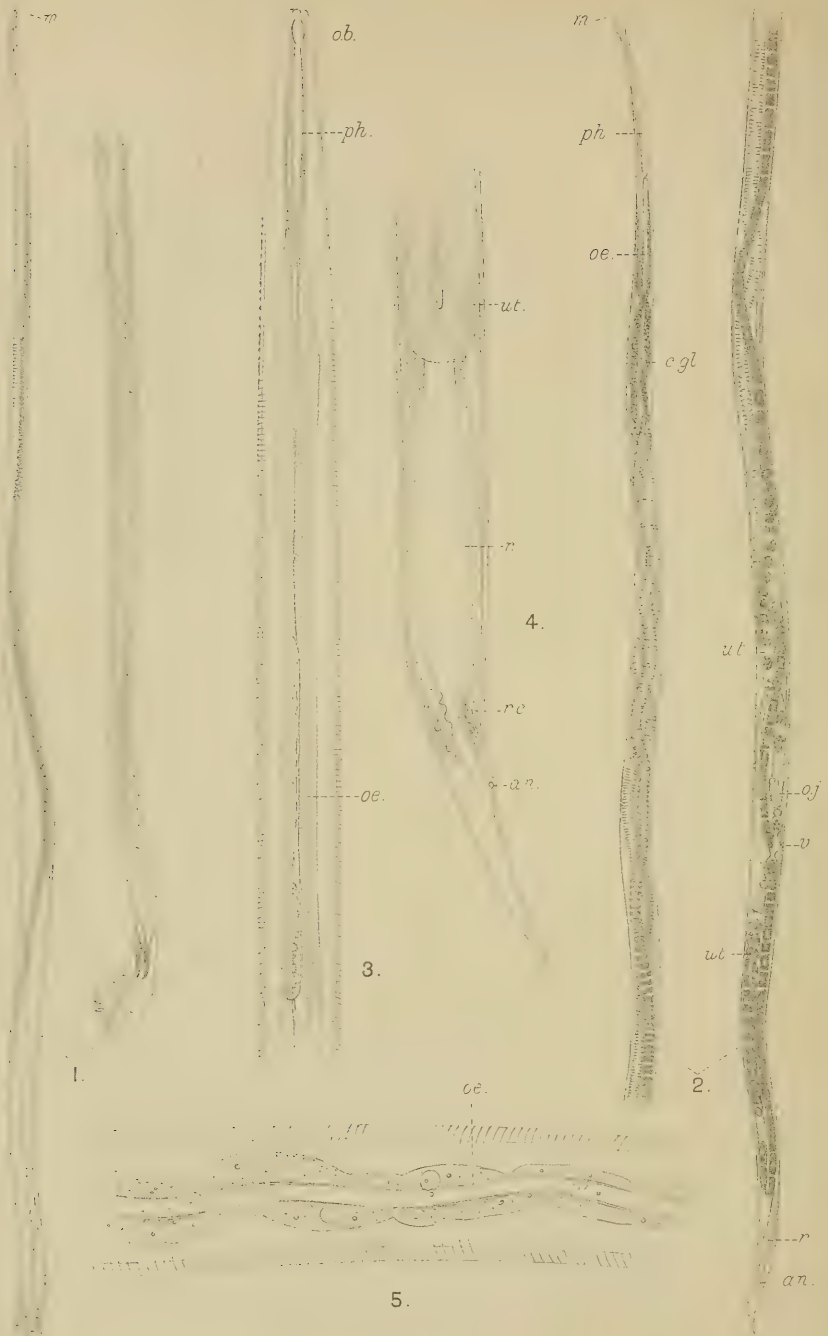
- Fig. 26. The larva of *Scatophaga stercoraria* L. A. Life-size: B. magnified. *a.s.* anterior spiracle, *p.s.* posterior spiracle, *h.s.* hypostomal sclerite, *m.s.* mandibular sclerite, *ph.s.* pharyngeal sclerite, *v.t.* visceral trachea, *t.c.* transverse commissure.
 27. Enlarged view of oral and pharyngeal sclerites, lettering as in fig. 26. *d.g.* dental sclerite.

PLATE XLVI.

- Fig. 28. Enlarged view of head of the maggot, showing *a.s.* anterior spiracles, spines, more pronounced at the anterior end of each segment, *m.* mouth, *f.b.* fat-body; other lettering as in fig. 26.
 29. Lateral view of mouth of the maggot, showing sensory papillæ. Magnified.
 30. Dorsal view of the head of the maggot, showing the anterior spiracles protruded. Magnified.
 31. Dorsal view of posterior end of maggot, showing *p.s.* posterior spiracles, the split tracheal main trunks and papillæ. Magnified.
 32. Lateral view of the same, showing *a.* the anus. The specimen was slightly compressed and the posterior spiracles were a little displaced and both brought into view.

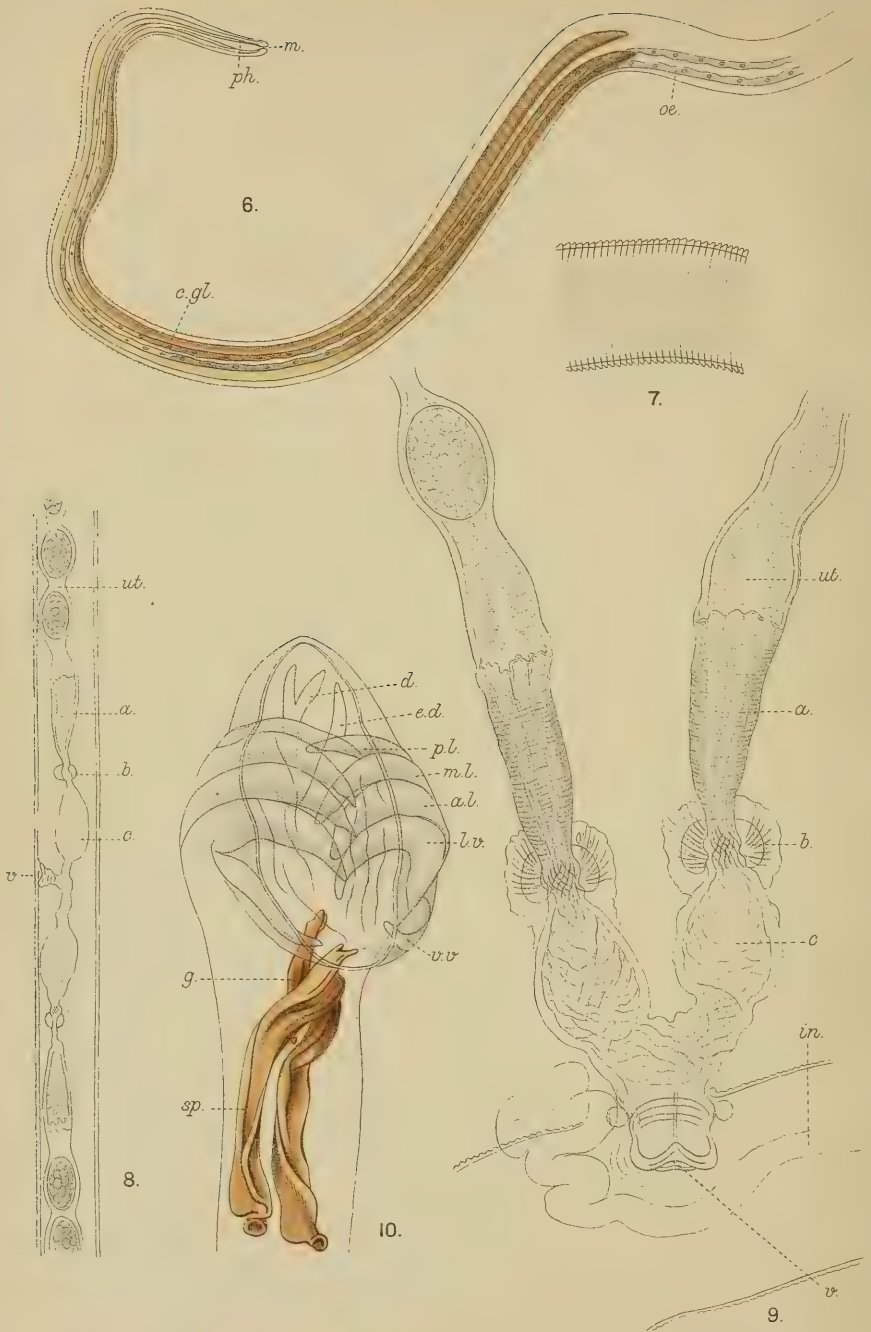
PLATE XLVII.

- Fig. 33. Side view of male specimen of *Ceratophyllus gallinulæ* Dale.
 34. Side view of female specimen of the same drawn to scale.



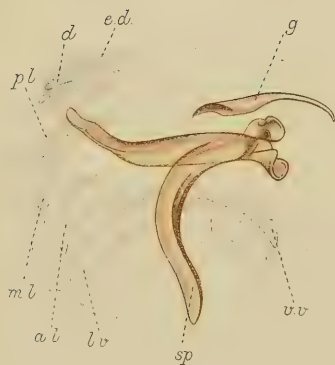
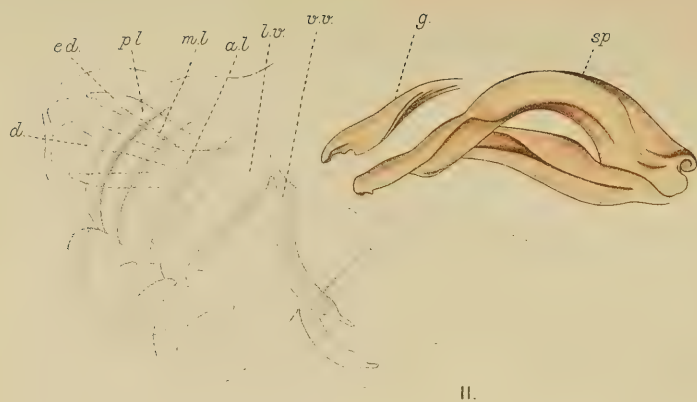
TRICHOSTRONGYLUS PERGRACILIS.

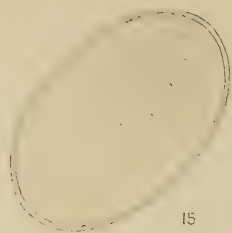
E. Wilson, Cambridge.



E Wilson, Cambridge.

TRICHOSTRONGYLUS PERGRACILIS.





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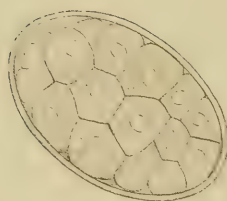
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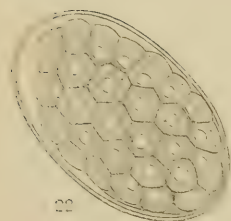
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20.



21.



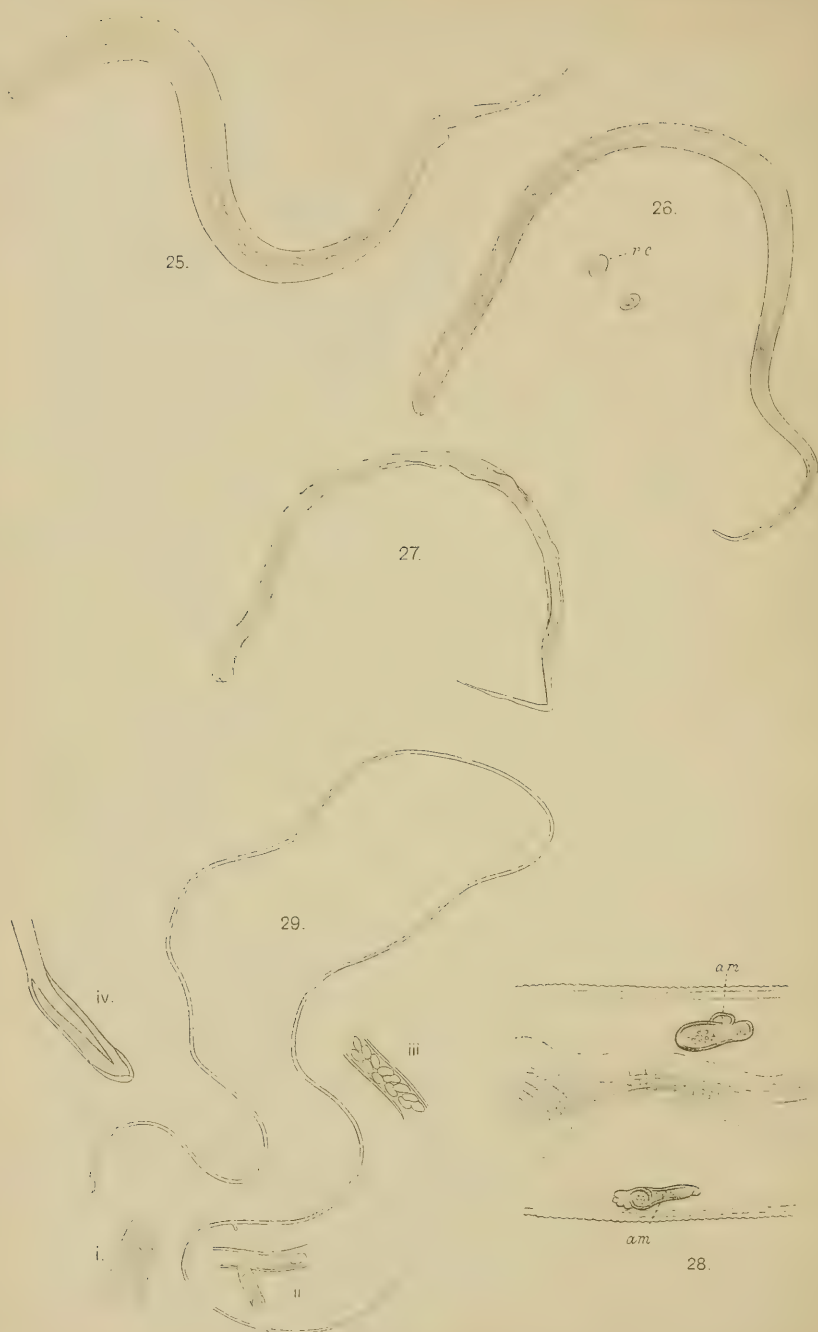
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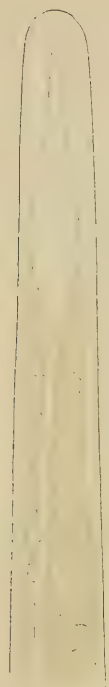
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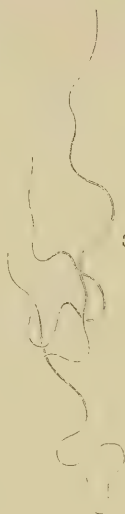
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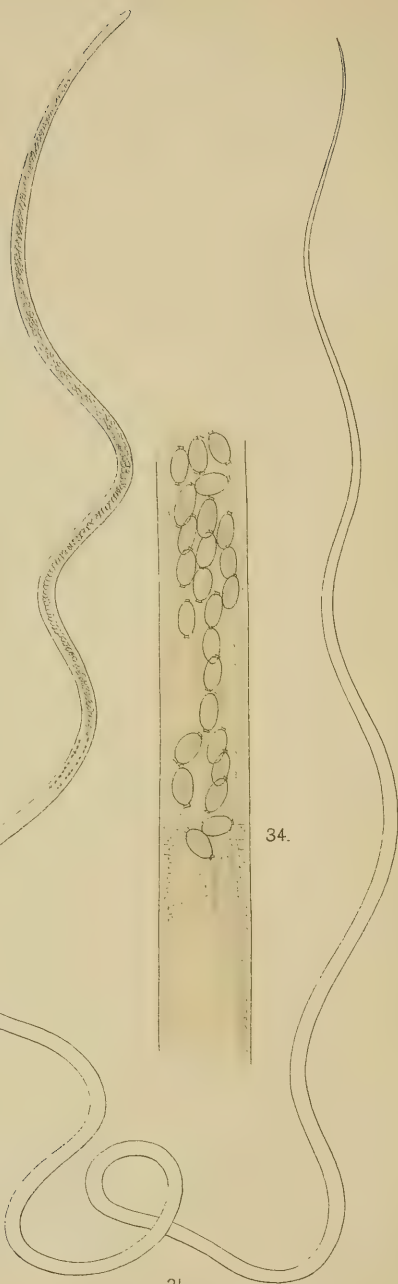
TRICHOSTRONGYLUS PERCRACILIS
AND TRICHOSOMA LONGICOLLE



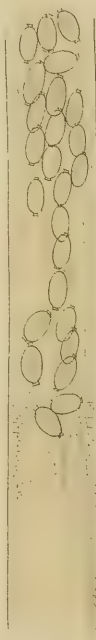
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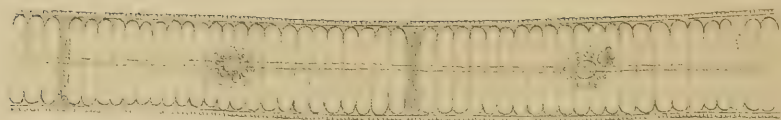
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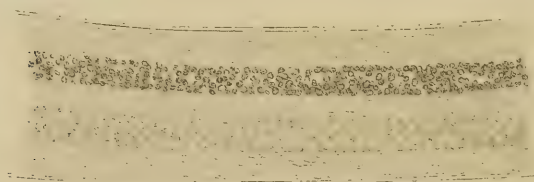
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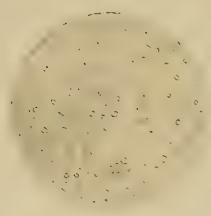
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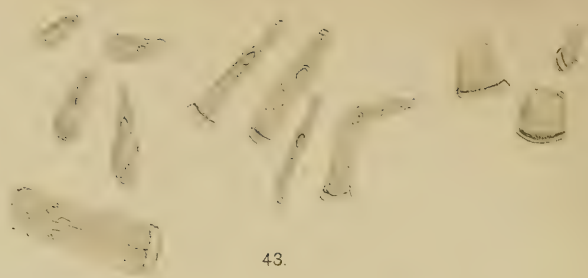
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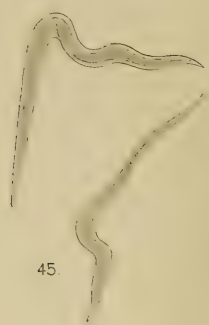
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43.



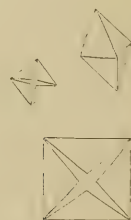
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46.



2. The Thread-Worms (*Nematoda*) of the Red Grouse (*Lagopus scoticus*). By A. E. SHIPLEY, M.A., Hon. D.Sc., F.R.S., F.Z.S., Fellow and Tutor of Christ's College, Cambridge, and Reader in Zoology in the University.

[Received December 12, 1908.]

(Plates XLVIII.—LV.)*

NEMATODA. Thread-worms or Round-worms.

(i.) Family **Strongylidæ**.

(i.) *TRICHOSTRONGYLUS PERGRACILIS* (Cobbold).

Synonym: *Strongylus gracilis* Cobbold.

HISTORY.

This round-worm was first described under the name of *Strongylus pergracilis* Cobbold, by Cobbold † whose words we quote:—

"*Characters*.—Body filiform, finely striated, gradually diminishing in front, uniform in thickness below; head bluntly pointed, with a simple oral aperture; tail of the male furnished with a bilobed bursa, each half supporting four pointed rays; spicules two, thick, and slightly divergent; tail of the female slightly swollen above the subterminal anal orifice, rather sharply pointed at the tip; vaginal opening situated at the upper part of the inferior sixth of the body.

"Length of male $\frac{1}{3}$ " to $\frac{2}{3}$ "; body $\frac{1}{400}$ " in diameter, tapering anteriorly to $\frac{1}{2000}$ " at the head; greatest breadth immediately above the bursa $\frac{1}{350}$ ".

"Length of female mostly $\frac{2}{3}$ ", sometimes very nearly $\frac{1}{2}$ "; breadth above the tail $\frac{1}{200}$ " to $\frac{1}{250}$ ", narrowing at the extreme point to $\frac{1}{7000}$ "; longitudinal diameter of the eggs $\frac{1}{250}$ ", their breadth being $\frac{1}{650}$ ".

Eight years later Cobbold described ‡, under the name of *S. douglassii*, a nematode which occurred in great numbers in the proventriculus of certain South African ostriches. Their presence was associated by the ostrich-farmers with a certain amount of disease and with some deaths.

Two other allied forms, *Trichostrongylus (Strongylus) nodularis* and *Trichostrongylus (Strongylus) tenuis*, are also held to cause disease in birds, whilst recently a fifth form, *S. quadriradiatus* (possibly also a *Trichostrongylus*), has been added by Stevenson § to the list of the Strongylids harmful to birds.

* For explanation of the Plates see p. 349.

† 'The Grouse Disease,' 'The Field' Office, London, 1873.

‡ J. Linn. Soc. London, Zool. xvi. 1883, p. 184.

§ U.S. Dept. Agric., Bureau Anim. Industry, Circular 47, 1904.

*T. nodularis** Rud. is found in the mucous and muscular coats of the stomach and duodenum of many species of Anatidæ. It has frequently been observed in the domestic goose and is especially fatal to the young of this bird.

T. tenuis Eberth† occurs in the cæcum of the grey goose, *Anser cinereus* Meyer, and of the domestic goose. Neumann states that it is "rare."

Finally, we have the species *S. quadriradiatus* recently described by E. C. Stevenson. It occurred in considerable numbers in the intestines of a flock of fancy pigeons which had been almost destroyed by a malady of unknown origin early in 1904. In his article upon this epizootic, Stevenson points out that the presence of a few nematodes in the cæcum of the pigeon causes little harm. If, however, the thread-worms exist in large numbers, disease becomes manifest. This Stevenson attributes to two causes: the first is the loss of blood; but there is, I think, little or no evidence that these nematodes live on blood. The second cause is the piercing of the walls of the intestine‡, which permit the bacteria of the contents of the alimentary canal to make their way into the peritoneal cavity, where they set up peritonitis. Evidence is gradually accumulating as to the occurrence of this, and some of the French authorities even think that such a perforation, made as a rule by *Trichocephalus dispar*, is one of the more common, if not the most common, causes of appendicitis in man. The presence of these worms further sets up an inflamed, catarrhal condition of the walls of the intestine, which leads to a debilitating diarrhœa and to general disorders of the digestive system. As in other cases, the Nematodes doubtless give off toxins, the effect of which is largely confined to the nervous system and to the cells in the blood of the host.

STRUCTURE.

The genus *Trichostrongylus* has recently been established by Looss§ to include certain forms which he has separated out from the large genus *Strongylus*. The *Strongylus pergracilis* of Cobbold corresponds so closely in structure with the species described by Looss that I think there can be no doubt that it also should be included in the new genus. The suggestion made above that *Strongylus tenuis* Eberth of the goose should also be reckoned as a species of *Trichostrongylus* was made to me by Mr. R. T. Leiper.

Specimens of *T. pergracilis* are found in the cæca of grouse. They are apt to cover themselves with mucus and dirt, and are

* Wedl, SB. Akad. Wien, xix. p. 46, and Schneider, Monogr. d. Nematoden, p. 143.

† Würzburger nat. Zeitung, ii. p. 47. Von Linstow, Troeschel's Archiv, i. 1876, p. 3.

‡ An actual perforation of the membrane is not in all cases necessary. There are examples of bacteria traversing the wall or parts of the wall of the alimentary canal which have been locally or temporarily weakened in some way.

§ Centrbl. Bakter. Parasitenk. xxxix. 1905, p. 409.

consequently hard to see and often overlooked. We have found them, with hardly an exception, in every one of the hundreds of grouse examined. They are rendered opaque and white, and hence much more apparent, by shaking up the contents of the cæcum in 75 per cent. alcohol, to which a few drops of corrosive sublimate have been added. Their presence is also readily detected by compressing a drop or two of the cæcal contents between two microscope-slides and holding them up to the light. The worms, if there be any, then appear as thin, white, transparent lines. We owe this method to Dr. Wilson.

T. pergracilis is an extremely fine worm, measuring in the male on the average 6 to 8 mm. and in the female 8 to 10 mm. They are very narrow and hair-like and, as a rule, whitish in colour, but sometimes have the tinge of blood when seen in a very thin layer on a slide through the microscope. They are very transparent, readily revealing their internal structure, and they are so soft that the pressure of a cover-slip almost always ruptures them. The cuticle is very clearly and definitely ringed (Pl. XLVIII. figs. 3 & 5), and the rings are so constituted that whilst the worm can easily work its way forward through a tissue, it would have difficulty in wriggling backward. The rings give the edge of the body a strongly serrated appearance like a saw. This is most marked a little way behind the head and extends over about one-third the body length. There is no trace of longitudinal marking on the cuticle.

The genital bursa in the male is well formed, and opens to the exterior by an oval opening with its long axis longitudinal. The bursa is supported by a number of ridges as an umbrella is by its ribs, and, using Looss's nomenclature, these are arranged in three groups. The members of each group arise from a common root and are recognisable, even when, as in the case of *T. pergracilis*, some of them run close to and parallel with members of another group. The three groups are: (1) Dorsal, (2) Lateral, (3) Ventral.

The Dorsal group consists of a median, *posterior dorsal* rib, which is forked slightly at its free end; from the same root with it arise a pair of *externo-dorsal* ribs, one of which passes into the side membrane of the bursa (Pl. L. figs. 11 & 12). In front of the *externo-dorsal*, three *lateral* ribs arise from a common root; on each side of these the most posterior or *postero-lateral* rib is smaller than the others and slightly separated from them; the *median-lateral* rib and the *antero-lateral* rib are of similar size and lie parallel. There are on each side in front of the lateral ribs a pair of *ventral* ribs; of these the hindmost or *latero-ventral* rib forsakes its group and comes to lie close and parallel to the *antero-lateral* rib, which it further resembles in size and shape. The *ventro-ventral*, on the other hand, is slimmer and stretches forward to support the anterior edge of the bursa. The whole arrangement of the lateral and ventral ribs recalls a slightly flexed hand, with the thumb thin and extended and the little finger slightly divaricated. The thumb represents the *ventro-ventral* rib, the first finger the

latero-ventral rib, the second finger the antero-lateral rib, the third finger the medio-lateral rib, and the little finger the postero-lateral rib (Pl. XLIX. fig. 10).

The spicules in the male are very conspicuous and very difficult to describe. Figures 11, 12, 13 on Pl. L. give a better idea of their appearance than any verbal description can. They are short, strongly chitinated, with thickened edges and a kind of haft or base at the anterior end; and each spicule is hollowed something like a crumpled, withered, lanceolate leaf. Each spicule is provided with retractor and protractor muscles, and, as fig. 12 shows, when protracted they are divaricated. When in this extruded condition they form a cross, the left spicule projecting to the right and *vice versâ*. Besides the spicules and between them, rather to the posterior end, lies the accessory or median piece, which Looss calls the "gubernaculum." It is best seen in profile, and has then somewhat the outline of a Turkish slipper. It also has muscles inserted into its ends.

Near the base of each spicule is an oval clear vesicle, but apparently the end of the spicule was outside and not inside the lumen of the vesicle.

The head presents very little signs of differentiation (Pl. XLVIII. fig. 3). In some specimens with a one-twelfth objective three very minute lobes can be seen, but they are not visible in all cases and their appearance may be due to some expansion of the mouth. The mouth is terminal and leads into a slightly bulb-like cavity which soon narrows into the thin capillary lumen of the alimentary canal. The œsophagus is more granular than the intestine, and separated from it by a very shallow groove; its walls consist of flatly rounded cells with conspicuous nuclei (fig. 5). I could not detect any parts in the intestine; it appears to be an undifferentiated tube running from mouth to anus, the lumen lined with chitin and the walls formed of granular cells with visible nuclei. No food was seen in the alimentary canal. Posteriorly the intestine widens into a spacious rectum, which just in front of the anus narrows again into a short, thin, terminal portion. The anus in the male opens into the genital bursa; in the female it is a little distance in front of the end of the pointed tail, but relatively not so far forward as it is in the larva. Two cervical glands run about a fifth of the length of the body backwards, and end with rounded ends about the same level.

In the male the testis begins about the level where these glands end. It consists of a single tube, the cells lining which give rise to the spermatozoa. Anteriorly the cells when squeezed out seem amoeboid, with rounded and very refringent nuclei. The hinder end of the testis is, however, crowded with spermatozoa shaped like little squat bottles, and in some specimens the genital bursa sheltered two clumps of these, looking as though they had escaped from two vesiculæ seminales.

I saw nothing of excretory canals or their opening, and unless an ill-defined ring which surrounded the alimentary canal, about

one-twenty-fifth of the body-length from the anterior end, be the nerve-ring, I saw nothing of the nervous system.

The ovaries are double. Each tube arises about the level or a little behind the level of the hinder end of the cervical glands. One of them runs, with but slight undulations, straight to the "ovejector" which opens by the vagina, situated about one-sixth of the body-length from the hinder end, the other passes the vagina and reaches back almost to the anus; it then doubles forward again and opens into the posterior "ovejector."

The anterior end of each ovary contains undifferentiated protoplasm, but soon eggs begin to appear. At first these are very flattened, like a pile of coins, much broader than they are long; then they become thicker, and, finally, three or four times longer than they are broad. The rounded nucleus is in every stage very conspicuous. It is impossible to say precisely where the ovary ceases and the oviduct begins. We find the long cylindrical cells rounding themselves off and an egg-shell beginning to appear. By this time fertilization must have taken place, but I have not seen any spermatozoa in the oviduct. The oval cells usually lie at first with their long axis at right angles to the longitudinal axis of the oviduct; then, when a little older, they lie obliquely, and, finally, they come to lie with their long axes parallel to that of the duct, in which position they are most readily swallowed by the "ovejector." The anterior and the posterior oviducts usually contain one, two, or three unsegmented ova; then come some six to eight segmented eggs representing as a rule the stages with two, four, eight, sixteen, thirty-two, sixty-four, and sometimes a hundred and twenty-eight blastomeres. One or two of these stages may be represented by two ova, but in any case the segmentation must be very rapid.

The lower end of the oviduct is lined by what in optical section appear to be high columnar cells with very granular disintegrating borders. These seem to be secreting something. The walls of the oviduct pass suddenly into the "ovejector," which consists of three parts: (a) The most internal is somewhat funnel- or trumpet-shaped, its wider mouth is continuous with the walls of the oviduct and is crenellated; the funnel is richly supplied with both longitudinal and circular fibres; not infrequently it contains an egg. (b) The second chamber of the "ovejector" is spherical, very transparent, and is marked by the presence of a large number of radiating muscle-fibres running from the periphery to the limits of the lumen. The contraction of these fibres would enlarge the lumen and suck the egg on. (c) The third chamber of the "ovejector" is thin-walled, with a chitinous lining. It frequently shelters an egg. At its outer end it narrows, and uniting with the similar narrow end of its fellow it forms an extremely short vagina which opens to the exterior by a longitudinal slit, the edges of which are also crenellated.

The ova are laid in the fluid contents of the host's cæca, in which they are frequently found floating. We have found

developing ova in the cæca of a young grouse chick of 7 to 10 days of age from Auchenterlie, Dumbartonshire. Apparently the cæca are the chief centres of absorption of the digested food; they contain none of the cellulose skeletons of vegetable cells so common in the intestine, and none of the masses of cast epithelium which make up so large a proportion of the flocculent masses in the duodenum. The eggs *may* develop further inside the cæcum, though as yet we have not found an egg containing an embryo in its contents.

A small pellet of the cæcal contents, such as can be carried away on the point of a needle, spread out under a cover-slip, will, in a well-infected bird, show some 12–20 worms and 100–200 eggs in the field of a $\frac{2}{3}$ Ross' objective with a No. 2 eyepiece.

ALLIED SPECIES.

In his memoir on the genus *Trichostrongylus*, Looss enumerates the following four species:—

(1) *T. RETORTÆFORMIS* (Zeder), 1800. From the duodenum and exceptionally from the stomach of *Lepus timidus* and *Lepus cuniculus* (when undomesticated). Railliet says it coexists with *Strongylus strigosus*, and helps to give rise to a pernicious anæmia. It develops directly without intermediate host.

(2) *T. INSTABILIS* (Railliet), 1893. Syn. *T. subtilis* Looss, 1905. From the duodenum and exceptionally from the stomach of *Ovis aries*, *Ovis laticauda*, *Antilope dorcas*, *Camelus dromedarius* (Egypt), *Papio* (*Cynocephalus*) *hamadryas* (North Africa), and occasionally in Man (Egypt and Japan). Railliet states that this species, together with *Strongylus contortus*, lives in the duodenum of sheep, which succumb to pernicious anæmia.

(3) *T. PROBOLURUS* (Railliet), 1896. From the duodenum of *Ovis aries*, *Ovis laticauda*, *Antilope dorcas*, and occasionally of Man (Egypt), and *Camelus dromedarius* (? Paris and Egypt).

(4) *T. FIBRINUS* Looss, 1905. From the duodenum of *Ovis aries*, *Ovis laticauda*, occasionally from *Camelus dromedarius* and Man (Egypt). Looss regards this as a rare species.

To these must be probably added:—

(5) *T. TENUIS* (Eberth), 1861. Syn. *S. tenuis* (Mehlis) Eberth, 1861. From the cæcum of the goose, *Anser cinerea*, and

(6) *T. NODULARIS* (Rud.), 1809. Syn. *S. nodularis* Rud., 1809; *Ascaris mucronata* Fröhlich, 1791; *S. anseris* Zeder, 1800; *S. nodulosus* Rud., 1803; *S. crispinus* Molin, 1850. From the mucous and muscular coats of the stomach and duodenum of various species of the family Anatidæ. They are said to be very fatal to young geese.

(7) *T. PERGRACILIS* (Cobbold), 1873. Syn. *S. pergracilis* Cobbold, 1873. From the cæcum of *Lagopus scoticus*.

(8) *T. QUADRIRADIATUS* (Stevenson), 1904. Syn. *S. quadriradiatus* Stevenson. From the intestines of pigeons.

(9) *T. EXTENUATUS* (Railliet), 1898. Syn. *S. gracilis* McFadyen, 1897, not Leuckart, 1842. This form occurs in the fourth stomach of cattle in England, and in cattle, sheep, and goats in the United States*.

(10) *T. CAPRICOLA* Ransom, 1907. From goats and sheep in the United States.

It is noticeable that the parasite occurs only in vegetable feeders, and that, whereas it lives always in the stomach or the duodenum of Mammals, it chiefly inhabits the cæca of Birds.

PARASITES OF *TRICHOSTRONGYLUS PERGRACILIS* (Cobbold).

In a female specimen two amœboid organisms were making their way along the body-cavity in the region of the "ovejector." Each was throwing out rounded pseudopodia, and the distinction between the granular endosarc and the glassy ectosarc was very sharp. Another specimen had some refringent bodies, in shape like short rows of yeast-cells or fungi-spores, lying in the body-cavity (Pl. LIII. fig. 32).

LIFE-HISTORY OF *TRICHOSTRONGYLUS PERGRACILIS* (Cobbold).

The eggs are found in all the earlier phases of segmentation in the fluid contained in the intestinal cæca of the grouse, and usually attain there a stage of 32 or 64 blastomeres. Removed from the body and kept in a watch-glass in water at the temperature of a warm room they continue to segment until in the course of twenty-four hours the larvæ, typically coiled in the egg-shell (Pl. LI. fig. 23), are found. A slight pressure on the egg-shell causes a rupture, the shell instantly contracts (compare fig. 24 with fig. 23 on Pl. LI.), and the larva begins to come out.

Exactly similar stages of development are found in the fæces of the grouse, both in the rectum and after leaving the body, and the ova containing the coiled embryos of the *Trichostrongylus* are common in grouse-droppings. A microscopic examination of these droppings reveals a wonderful collection of objects. In one specimen alone we found (1) moss-spores and undigested moss-capsules, (2) bits of *Spirogyra*, (3) diatoms, (4) the hyphæ of some fungus, (5) undigested epidermal cells showing stomata from a leaf, (6) spiral woody fibres, (7) bacteria, (8) portions of feathers, (9) the leg of a spider, (10) specimens of *Amœba* or of amœboid organisms, (11) cestode eggs, (12) eggs and the head-end of *Trichosoma longicollis* Rud., (13) eggs with larva of *Trichostrongylus pergracilis* (Cobbold), (14) crystals which are the same as those which abound in the cæca. Two kinds of these are abundant, one resembling the Charcot-Leiden crystals, the presence of which is usually associated with parasites in the intestine, the other resembling the crystals of magnesium ammonium phosphate, $Mg(NH_4)(PO_4) \cdot 6H_2O$. Doubtless further search would

* B. H. Ransom, U.S. Dept. Agric., Bureau Anim. Industry, Circular 116, 1907.

result in the discovery of many other objects. The important fact from our point of view is that the expelled faeces contain ova within which are fully formed larvæ ripe for hatching. But we have also found hatched larvæ in the faeces which were still in the rectum, so we may conclude that the droppings may contain (1) larvæ coiled in the egg-shell, and (2) larvæ which have escaped from the egg-shell and are living freely.

No one has ever seen, and probably no one will ever actually see, one of these eggs or larvæ of the thread-worm enter the body of the grouse, but that they do so directly is, I think, unquestionable. Railliet* and Ransom† have both succeeded in infecting rabbits by directly feeding them on the embryos of *T. retortaeformis*; and presumably the development of *T. pergracilis* is also, like that of its congener, accomplished without an intermediate host. In Ransom's case the embryos apparently hatched out and developed to the ensheathed stage within two weeks after the passage of the eggs from the intestine of the host, and the embryos when swallowed by a second rabbit became mature and capable of laying eggs in about a month after they had been swallowed. The thread-worms exist in hundreds in every bird; the female thread-worms, which greatly exceed the male thread-worms in number, lay thousands of eggs. The eggs and larvæ exist in countless numbers in all grouse-droppings. As these are disintegrated by rain and frost, these minute organisms are either washed by the water on to all the food or pebbles a grouse may pick up, or in the absence of rain are dried and blown by the wind all amongst the heather and other food which a grouse may eat. The ova and larvæ of thread-worms are notoriously resistant to the effects of desiccation, so that even in the event of prolonged droughts—which, judging from my experience of Scotland, must be a remote contingency—the eggs and larvæ are in no way prevented from reaching their host‡.

During a visit to Beaufort Castle in August, 1908, I introduced what has since, in the hands of Dr. E. A. Wilson, proved a valuable instrument in research. We had hitherto been unable to find the ova or the young nematodes upon the heather; they are so minute and require so high a power of the microscope to see them, that all attempts to look at them on the stalks or in the buds had failed. The new method showed that nematodes, some of them free-living, and their larvæ and the larvæ of parasitic forms exist in countless thousands in every square foot of heather.


The method consists in soaking a handful of heather in a glass bottle, using just as little water as will well cover the twigs, for several hours—overnight is not too long; then shaking the bottle well for some minutes, or shaking it more gently in a rocker

* Bull. Soc. Zool. France, xiv. p. 375.

† U.S. Dept. Agric., Bureau Anim. Industry, Circular 116, 1907.

‡ Since the above was written, Mr. R. T. Leiper has obtained all the stages of the life-history of *T. pergracilis* and has succeeded in infecting hand-reared grouse which were previously free from the worms.

for a longer period, and allowing the sediment to settle. The sediment is then, with as little water as possible, taken up by a pipette and placed in the test-tube of a centrifugal machine. After a few minutes' rapid rotation the heavy matter which accumulates at the closed end of the test-tube is removed and examined microscopically. The very first time we tried this method we succeeded in showing that heather is, so to speak, "crawling" with thread-worms, amongst which we thought we recognised the larvæ of *T. pergracilis*. We also found aphides, a dipterous larva, thousands of pollen-grains, tardigrades, thysanura, rotifers, nematodes, vegetable debris, desmids, beetle-larvæ, young hemiptera. One of the nematodes had striated cuticle and was about the proportions of *T. pergracilis*; some of the others were relatively much longer and seemed to be free-living. Amongst the nematodes was a male with the characteristic spicules of the *T. pergracilis*, of the same sort of outline and in the same relative position. The tail was curved and showed as yet no genital bursa. The mouth led into a short

oesophagus () with a small swelling. The body contained a granular substance.

These eggs and larvæ must exist in quite countless millions, every dropping must contain many thousands; roughly speaking, a grouse—at any rate during the night—relieves itself about once an hour, and the droppings occur every few yards on the moors. Hence the occurrence of *Trichostrongylus pergracilis* even in grouse chicks of a tender age is readily explained.

One must not forget that a grouse-dropping consists of two parts: (1) the excreta from the intestine, which contains the tape-worm and *Trichosoma* eggs; and (2) the more fluid contents of the cæca, which alone contains the *Trichostrongylus* eggs and larvæ. This excretion usually forms a cap upon the firmer dejecta from the intestine, but sometimes occurs alone; in either case it probably is washed away by the first rain or quickly dries up, whilst the more solid excreta will retain their shape for a couple of years before disintegrating, as is shown by finding them unchanged in shape but with charred ends on moors that were burnt some two years ago.

We have seen that a young grouse-chick, not more than ten days old, contains in its cæca segmenting ova, young larvæ, and adult males and females, and we are faced with the old problem as to whether the egg preceded the fowl or the fowl the egg. Are the segmenting ova we find in these young cæca of the same generation as the larvæ and adults, or are they the offspring of the adults? On the whole, I incline to the second alternative. I think most probably that the larvæ, either coiled up in the egg-shell or free, obtain access to the alimentary canal with the food or water, make their way to the cæca, and there, remote from the world, in the warmth and obscurity of their narrow home, rapidly mature, couple, and quickly begin to lay eggs, and that these

eggs are those which we find in the cæca of the young grouse-chick.

This, then, appears to be the ordinary life-history of *Trichostrongylus pergacilis*, but it is sometimes varied, and varied in a way which may have a bearing upon grouse-disease. We have seen that as a rule eggs with coiled-up larvæ leave the body of the bird, but we have also seen that free larvæ have sometimes been found in the fæces whilst still in the rectum. We have further discovered small nematode larvæ in the contents of the small intestine. These larvæ are more pointed than the larvæ we have watched hatch out from the *Trichostrongylus* eggs; still they may be the larvæ of this species*. Dr. Wilson has further found on one or two occasions both in the lungs and in the liver certain larval forms which resemble the larvæ we have artificially hatched out of the developing eggs of *T. pergacilis*, and the larvæ which we have found in the dejecta of the grouse.

These larvæ are extraordinarily minute, and unless seen alive are very difficult to recognise even under a twelfth oil-immersion. Hence they have hitherto been overlooked by researchers who have necessarily had to deal with grouse that had been dead for many hours, often for days. If these larvæ be in truth the young forms of *T. pergacilis*, then under certain—at present undetermined—conditions, they either *proprio motu* or carried by the blood-stream reach the two important organs, the liver and the lungs. The cavity of the alimentary canal is infested with bacteria, all very well in their place, but liable to become pathogenic if carried to other tissues and organs. It is improbable that these larvæ with their smooth, dry, “polished ivory” surface carry such bacteria adherent to their outside, but it is quite possible that feeding as they do on the fluid contents of the digestive tract they ingest such bacteria, and during their “Wanderjähre” deposit them undigested in just those organs where their pathogenic properties are most easily stimulated.

Apart from the harm thus caused, the presence of the *Trichostrongylus* produces grave local troubles, such as inflammation, peritonitis, ulceration, &c., which will be dealt with by the pathologists now working for the Inquiry.

(ii.) *SYNGAMUS TRACHEALIS* von Sieb.

The Red or Forked-Worm.

We have found this common pest of the fowl-yard and pheasant-coop but twice in the grouse. Probably their free and unconfined life, together with the comparative paucity of earth-

* It is also possible, and perhaps more probable, that they are the young of *Trichosoma longicolle* Rud.

worms in the moors, protects grouse from the "gapes," as the disease caused by the forked-worm is called. Earthworms abound in Scotland in the cultivated lands, pastures, and woodlands, and occur even on the tops of mountains. Mr. Wm. Evans tells me he has a list of seventeen species of the Lumbricidæ taken north of the Tweed, but they are practically absent from the peat-moors, where heather, grouse, and humic acid are most abundant. Some moors, however, such as those on the Pentlands, include patches of land in which worms flourish. Still there seems no reason at present to incriminate the forked-worm of causing any trouble at grouse. One of our cases was a young bird from Argyllshire.

(ii.) Family **Trichotrachelidæ**.

(iii.) *TRICHOSOMA LONGICOLLE* Rud.

Synonyms: *Calodium caudinflatum* Molin.

Trichosoma gallinum Kow.

Trichosoma caudinflatum Kow.

HISTORY.

This genus, first named and described by Rudolphi*, is also described by Dujardin† from various species of gallinaceous birds. He gives a list of the earlier and ill-defined synonyms. The species is also mentioned by Diesing‡ under the same name. It is recorded by Molin§ under the name *Calodium caudinflatum*, the name referring to the swollen tail of the female, from the small intestine of the partridge and the quail. Eberth||, who gives the best account of the anatomy of the genus *Trichosoma*, gives a short description and a figure of a nematode under the same name, *Trichosoma longicolle*; he draws attention to Dujardin's description of a funnel-like appendix to the vagina and surmises that this is a prolapsed piece of the vagina; this is undoubtedly the case in some of our specimens (Pl. LII. fig. 29, ii.). Kowalevsky¶ mentions under the name *Trichosoma gallinum* what Dr. von Linstow tells me is this species, and in a later paper** apparently describes and figures this under the name *Trichosoma caudinflatum*. Unfortunately I have been unable to read this, as the paper is written in Polish. Railliet†† considers that the *Trichosoma longicolle* described by Dujardin and Eberth does not agree with Rudolphi's description of his *Trichosoma longicolle*. He points out that Dujardin and Eberth's species

* C. A. Rudolphi, 'Entozoorum Synopsis,' Berlin, 1819.

† M. F. Dujardin, 'Hist. Nat. des Helminthes,' p. 19.

‡ C. M. Diesing, 'Systema Helminthum,' 1850-51, ii. p. 260.

§ R. Molin, S.B. Ak. Wien, xxxiii. 1859, p. 302, and Denk. Ak. Wien, xix. 1861, p. 330, also Mem. Ist. Veneto, ix. 1860, p. 617.

|| C. J. Eberth, 'Untersuchungen über Nematoden,' Leipzig, 1863.

¶ M. Kowalevsky, Bull. Ac. Cracovie, 1894, p. 280.

** M. Kowalevsky, Rospr. Ak. Krakov. xxxviii. 1901, p. 274.

†† A. Railliet, 'Traité de Zoologie Médicale et Agricole,' Paris, 1895.

occurs in the cæcum of the fowl and of the guinea-fowl, and he renames this species *Trichosoma retusum* Raill., 1893. The length of this worm is 13 mm. in the male, 19 mm. in the female. Rudolphi's worms—which may belong to more than one species—vary from 39 to 80 mm., and have been described from *Lyrurus* (*Tetrao*) *tetrix*, the Black Grouse, Black-cock, or Grey-hen; *Tetrao urogallus*, the Capercaillie; *Gallus gallinaceus*, the Common Fowl; *Ihasianus colchicus*, the Common Pheasant; *Chrysolophus* (*Phasianus*) *pictus*, the Golden Pheasant; *Perdix cinerea*, the Common Partridge; and *Coturnix communis*, the Common Quail.

We first found specimens of *T. longicolle* in a Perthshire grouse which was brought us in the morning we were leaving Blair Atholl for the south in the autumn of 1906. Having once seen it, however, it was soon observed again, though it occurs sparingly. It always lives in the duodenum, sometimes associated with the tape-worm *Hymenolepis microps*, and sometimes alone. The worms resemble short pieces of very fine white silk.

This species has two longitudinal rows of dark spots irregularly scattered in two lateral bands. Roughly speaking, there are five or six of the spots in a transverse row, but they are not regularly arranged. The two bands arise anteriorly in the region of the œsophagus, and as they pass backward they become somewhat narrower, much more pronounced in appearance, and darker. They end on the extreme end of the body (Pl. LIV. fig. 36). Each spot corresponds with a unicellular gland, and the bands of these glands replace the ordinary nematode excretory system in the Trichotrachelidæ, the family to which *Trichosoma* belongs. They have been best described by Jägerskiöld*. Each cell opens by a minute straight duct which traverses the cuticle and forms what used to be called the rod-shaped body (Pl. LIV. fig. 37). The *Trichosoma longicolle* of Eberth† has a third or ventral band, and he mentions that Dujardin saw but one band in his specimens.

The length of the specimens varied from 20 mm. in the male to 40 mm. in the female. The greatest breadth of the body was $4.5\ \mu$, but in the neck-region it did not exceed $3\ \mu$, and tapered away to the anterior end, where the breadth was but $0.5\ \mu$. The very regular large cells in the region of the neck, which are pierced by the œsophagus, are just under $3\ \mu$ in width and are $12\ \mu$ in length. In the young specimens these cylindrical cells with flat ends, lying like a lot of pillars end to end, are not cut up into a series of segments, which gives a scalloped outline to the cells of the adult when seen in profile. But later a number of circular constrictions arise, and these divide each cell into a series of ten or twelve areas upon each side, and the whole cell has the appearance of being built up of two rows of rounded bricks lying side by side in a double pile. The nucleus remains large, oval, and conspicuous. At the end of each cell there is

* Svenska Ak. Handl. xxxv. ii. (1901).

† 'Untersuchungen über Nematoden,' Leipzig, 1863.

usually a dark granulation which serves very clearly to define their limits (Pl. LIV. fig. 35).

The lumen of the œsophagus which pierces these peculiar cells is very minute, and is lined with a definite chitinous tube. The "cellular body," as the aggregate of the œsophageal cells is sometimes called, ends abruptly, about one-fifth the body-length from the anterior end. Here the œsophagus passes quite abruptly into the capacious intestine with its many-celled walls. Just at this point, and tucked away in the angle formed by the minute œsophagus widening into the broad intestine, are a couple of glands, probably the homologues of the cervical glands of other nematodes (Pl. LIV. fig. 38). The intestine continues to the hinder end of the body with no change; it is somewhat difficult to distinguish, as it is just about the same brown colour as the lateral lines. The posterior end of the female is truncated and the anus is at the ventral side of the abruptly terminated body.

The ovary is a single tube which anteriorly contains undifferentiated eggs. These gradually attain a definite and somewhat irregular outline. Posteriorly the ovary opens into a spacious uterus, in which the ova are oval, with a distinct vitelline membrane. The uterus is broad, and serves, with its contents, to conceal the other organs of the body. Posteriorly, where the body is wide, the ova are irregularly crowded together; there may be as many as five or six ova in a transverse row. Further towards the head the ova acquire their characteristic egg-shell with two bright spots at each end. They closely resemble the eggs of *Trichocephalus trichiurus* (*dispar*) (L.) (Pl. LIV. figs. 40 & 41). About halfway along the body the diameter lessens as we pass forward, and after a certain space the uterus is narrowed and only permits a couple of eggs to be abreast, and finally the eggs are reduced to a single row. The uterus opens by a vagina which is situated a little way behind the end of the "cellular body," *i. e.* just behind the anterior end of the intestine. The uterus or vagina is usually prolapsed and forms a bell-like structure, one edge of which usually has a clear oval vesicle in its walls (Pl. LIV. fig. 38). Through this bell-shaped structure the eggs pass out.

The male is markedly smaller than the female. Its average length is about 25 mm. and its width throughout does not surpass the anterior end of the female's body.

The testis is a single tube which opens posteriorly. At the tail end the male has a pair of cuticular folds or flanges, possibly representing a genital bursa. There is a single spicule, very long, and in many cases only perhaps protruded for a fourth or fifth of its whole length. It is described as having a sheath, but in the specimens we have seen this was not apparent—probably it was retracted (Pl. LIV. fig. 39).

The males are very much rarer than the females—in fact, we examined a considerable number of specimens without finding a single male, probably they occur in about the proportion of one to seven or ten females. We have occasionally found a very

long, thin larva in the duodenum, which we take to be the larva of the *Trichosome*.

The eggs appear to undergo no segmentation in the body of the worm, and, in fact, we have not yet seen an egg of *Trichosoma longicolle* segmenting. In one grouse from Ross-shire small embryos of some nematode were found in the small intestine. It is possible that these are the young of *T. longicolle*, but they show no trace of division into neck and body. It is also possible that they are the larvæ of *Trichostrongylus pergracilis*, but they differ in size and shape from those young of this species which we have hatched out and found free. The grouse in which they were found had been feeding on corn, and I am rather inclined to believe that these larvæ are the young forms of *Tylenchus tritici* which causes the well-known corn-cockle.

Trichosoma longicolle occurs only in the duodenum, often associated with the species of *Hymenolepis* which inhabits this part of the alimentary canal. They are surrounded by epithelial cells, singly and in clumps, and of many sizes and shapes, which have been shed in immense numbers from the wall of the duodenum (Pl. LV. figs. 42 & 43). These may be detached by post-mortem digestion. These worms have been found in 13·6 per cent. of the birds examined, but it must not be forgotten that they are most inconspicuous and easily overlooked. They have been found in grouse from Montgomeryshire and Yorkshire, as far north as Ross-shire, and at all seasons. They do not occur in large numbers and their pathological effect seems small; still we must not forget that their near ally, the human parasite *Trichocephalus trichiurus* (*dispar*), is one cause of peritonitis and appendicitis in Man.

However the nematode makes its way into the chick, it must, like the *Trichostrongylus*, grow very rapidly. We have found specimens in a grouse-chick of fourteen days in age.

(iii.) Family *Ascaridæ*.

(iv.) *HETERAKIS PAPILLOSA* Bloch.

Stossich* mentions this round-worm, under the synonym of *H. vesicularis* Fröhl., as occurring in the grouse. It is a very common parasite in poultry and pheasants. It occurs in the hand-reared birds at Frimley, and Dr. Cobbett and Dr. Graham-Smith have found 23 in one cæcum and 10 in the other in a grouse from Abbeystead which was free from *T. pergracilis*, and one in each cæcum of a grouse from Longtown, Cumberland, which had 108 *T. pergracilis* in one cæcum and 127 in the other, and the same number similarly distributed in a bird from Bolton Abbey, which had 3118 *T. pergracilis* in one cæcum and 2877 in the other.

* "Glasnik. Naravosl. druzt." (Societas historico-naturalis Croatica), Zagreb, 1887, p. 284.

(iv.) Family Filariidæ.

(v.) *FILARIA SMITHI* Sambon.

Dr. Sambon* has described a microfilaria or larval form of some species of *Filaria* in the blood of grouse. The adult forms of such larvæ usually live in the lymphatics and subcutaneous tissues; their larvæ pass into the blood and are conveyed to new hosts by some blood-sucking insects.

I am greatly indebted to Dr. E. A. Wilson, not only for most of the figures which he has kindly drawn, but also for much help during the working out of the material upon which this paper is based.

EXPLANATION OF THE PLATES.

All the figures have been drawn by Dr. E. A. Wilson. Figures 1 to 27 inclusive refer to *Trichostrongylus pergracilis*, figures 28 to 40 inclusive to *Trichosoma longicolle*.

PLATE XLVIII.

- Fig. 1. Male *Trichostrongylus pergracilis*, showing alimentary canal, spicules, and genital bursa. Magnified.
 2. Female *T. pergracilis*, showing œsophagus, cephalic glands, ovary, uterus with segmenting eggs, ovejector, and vagina. Magnified.
 3. Head end of the same. Showing mouth, oral bulb, pharynx, and œsophagus, also the cuticular ridges. More highly magnified.
 4. Tail end of the same. Magnified as fig. 3. Showing anus, rectum, rectal glands, and posterior loop of uterus.
 5. Portion of œsophagus of the same, showing arrangement of cells with large nuclei forming the œsophageal walls. More highly magnified.

PLATE XLIX.

- Fig. 6. Head end of same, showing cephalic glands. Magnified.
 7. Cuticle of same, one-third from anterior end, showing the ridges. Magnified.
 8. Vagina and the two ovejectors lying *in situ* in one straight line, and the two outer ends of the uteri containing segmenting eggs. Magnified.
 9. The ovejectors more highly magnified. The thread-worm has been crushed and the ovejectors have been pressed out and have come to lie parallel with one another. The lower ends of the uteri with their secreting columnar cells are seen, one of them contains a segmenting egg.
 10. Ventral view of posterior end of male, showing arrangement of ribs and of spicules. Highly magnified.

PLATE L.

- Fig. 11. Lateral view of the same, showing the spicules retracted. Highly magnified.
 12. The same, showing the spicules protruded and divaricated. Highly magnified.
 13. The same, seen ventro-laterally, showing attachment of muscles.
 14. Various views and stages of spermatozoa.

PLATE LI.

- Fig. 15. Unsegmented egg.
 16. Egg with two blastomeres.
 17. Egg with four blastomeres.
 18. Egg with eight blastomeres, only six showing.
 19. Egg with eight blastomeres, all showing.
 20. Egg with sixteen blastomeres.

* Jour. Trop. Med. and Hyg. x. 1907, p. 304. *Filaria smithi* cannot, however, stand, as the name is pre-occupied by Cobbold's species *Filaria smithi* from the Elephant, Tr. Linn. Soc. London, 2nd ser. ii. 1882, p. 237.

- Fig. 21. Egg with thirty-two blastomeres.
 22. Egg with sixty-four blastomeres.
 23. Egg with coiled-up larva, ripe for hatching.
 24. A similar egg, artificially ruptured, and the larva in the act of escaping.
 This shows the contraction of the egg-shell when ruptured.
 Figs. 15-24 inclusive are drawn to the same scale, and the last four or five from specimens artificially reared in a watch-glass.

PLATE LII.

- Fig. 25. A normally hatched embryo, a little older than the stage shown in fig. 23, found living in droppings of the grouse picked up on a moor.
 26. A slightly older larva, possibly of *T. pergracilis*, found in the lungs of a dying grouse.
 27. A similar specimen, still in the fluid of the lungs, but twenty-four hours after it was last seen alive. This explains why they are so easily overlooked.
 28. Two amœboid parasites in the body-cavity in the neighbourhood of the ovejector.
 29. A female *Trichosoma longicolle*. Magnified about ten times. (i) Shows the œsophageal cells, (ii) the prolapsed vagina, (iii) the uterus with eggs, and (iv) the slightly inflated tail.

PLATE LIII.

- Fig. 30. Three specimens of same. Magnified about twice.
 31. The same, magnified about seven times.
 32. Anterior end of the same. More highly magnified.
 33. Esophageal cell. More highly magnified.
 34. Uterus with eggs and alimentary canal.

PLATE LIV.

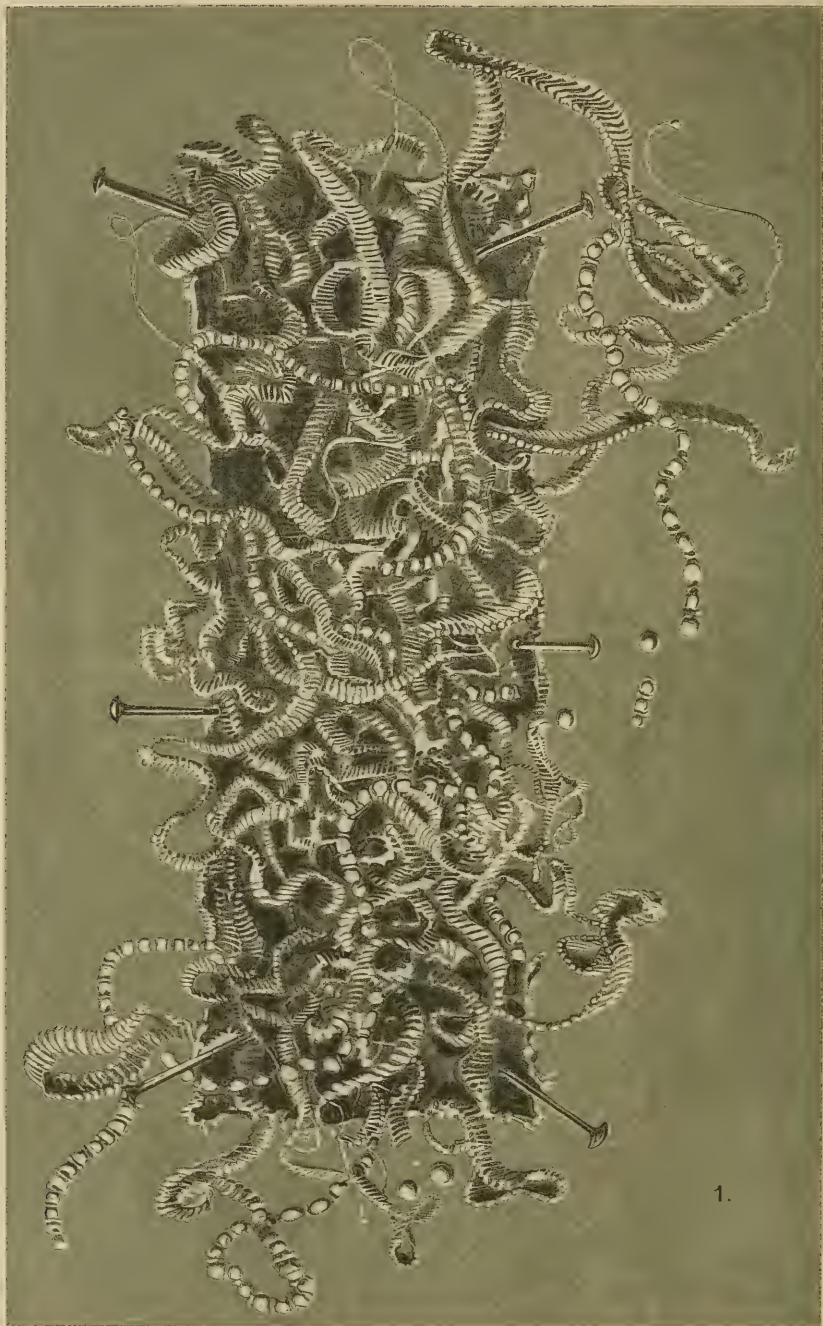
- Fig. 35. Esophageal cells, pierced by œsophagus, and showing granular nuclei and slightly ridged cuticle. Magnified.
 36. Optical section, showing right and left glandular bands. Slightly magnified.
 37. A glandular band seen in profile; the unicellular glands and their ducts are dark, the cuticle light. Highly magnified.
 38. The prolapsed vagina. Highly magnified. This view shows also the passage of the œsophagus into the intestine and the neighbouring glands.
 39. Posterior end of the male, showing spicule partially extruded. Highly magnified.
 40. Egg from uterus. Highly magnified.
 41. Egg in contents of intestine of the grouse.

PLATE LV.

- Fig. 42. Masses of epithelial cells which occur around the *T. longicolle* and which have been broken off the inner walls of the duodenum.
 43. The same, isolated and more highly magnified.
 44. Nematode larvæ found, on one occasion, in small intestine of the grouse.
 45. The same, more highly magnified.
 46. Crystals from rectum.

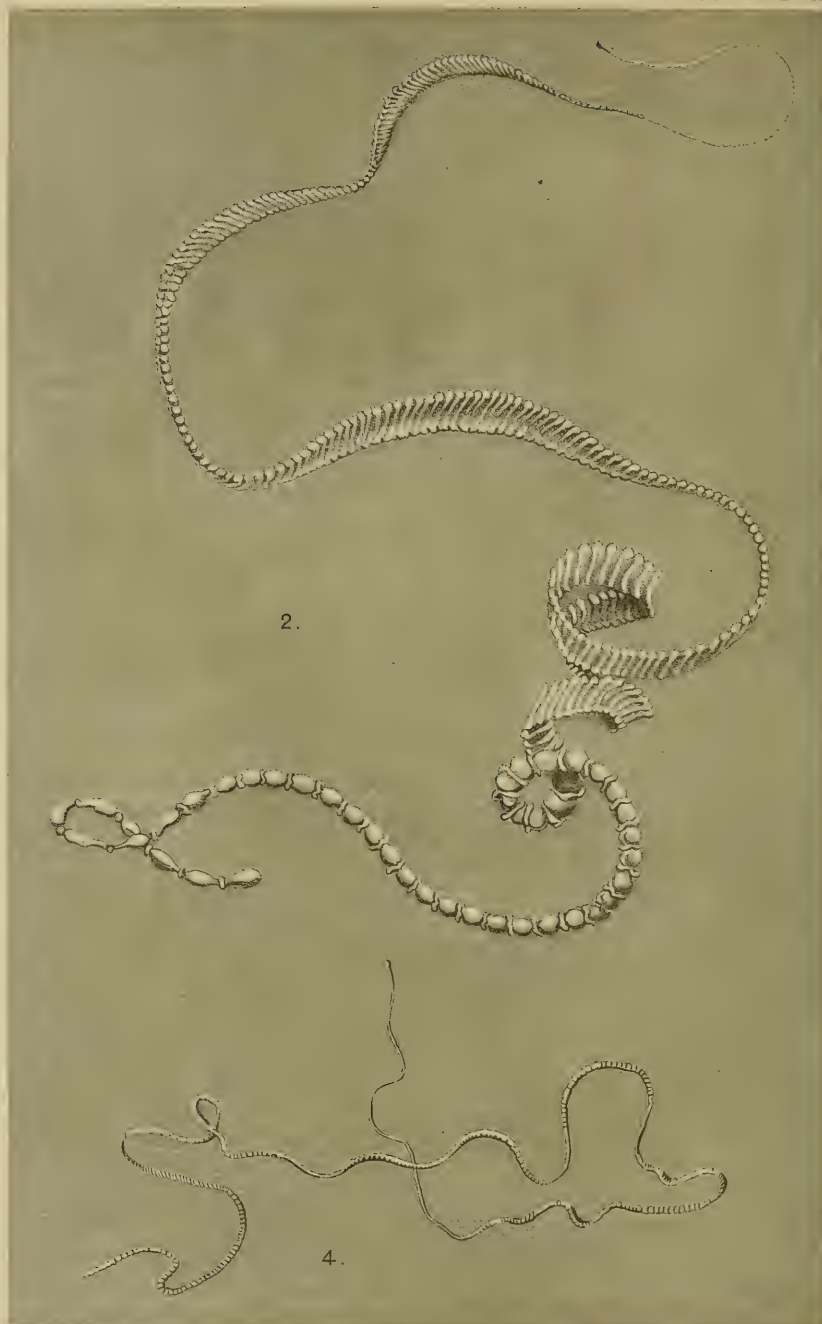
List of Reference Letters.

- | | |
|--|----------------------------------|
| <i>a, b, c.</i> The three chambers of the ovejector. | <i>o.</i> Ovary. |
| <i>a.l.</i> Antero-lateral rib. | <i>o.b.</i> Oral bulb. |
| <i>am.</i> Amœboid, parasitic organisms. | <i>œ.</i> Esophagus. |
| <i>an.</i> Anus. | <i>oj.</i> Ovejector. |
| <i>c.gl.</i> Cephalic glands. | <i>ph.</i> Pharynx. |
| <i>d.</i> Dorsal rib. | <i>p.l.</i> Postero-lateral rib. |
| <i>e.d.</i> Externo-dorsal rib. | <i>r.</i> Rectum. |
| <i>g.</i> Gubernaculum. | <i>r.C.</i> Rectal cells. |
| <i>in.</i> Intestine. | <i>sp.</i> Spicule. |
| <i>l.v.</i> Latero-ventral rib. | <i>u. & ut.</i> Uterus. |
| <i>m.</i> Mouth. | <i>v.</i> Vagina. |
| <i>m.l.</i> Median-lateral rib. | <i>v.v.</i> Vento-ventral rib. |

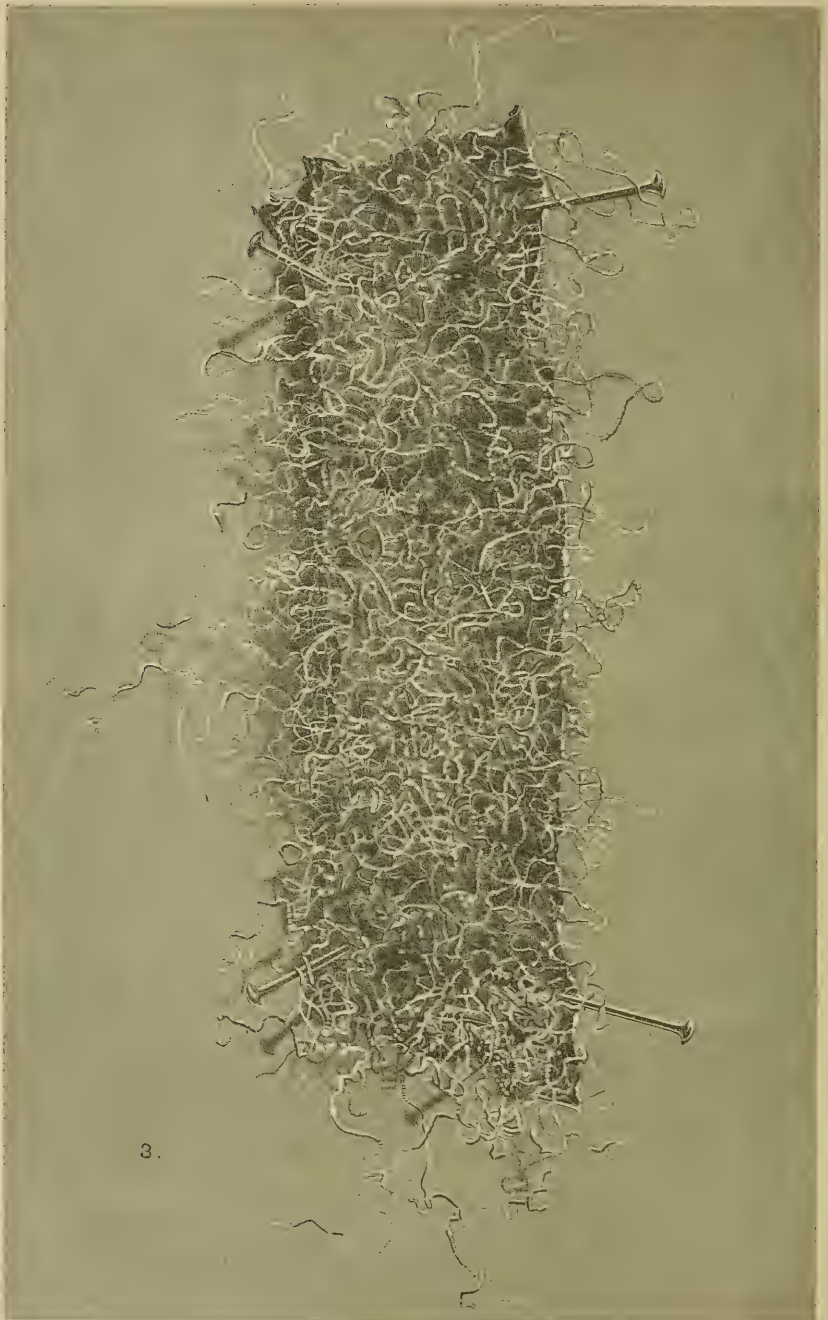


DAVAINEA UROGALLI.

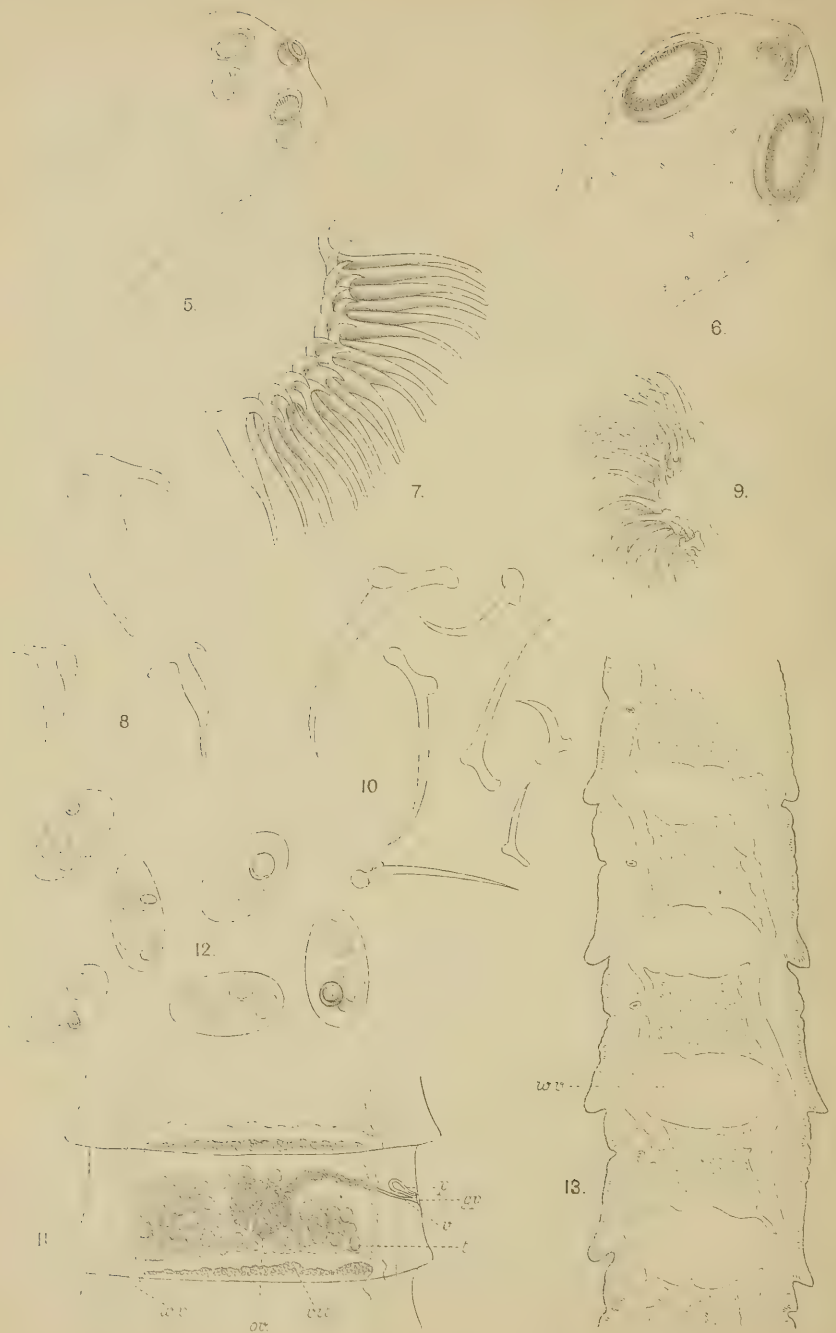
E. Wilson, Cambridge.

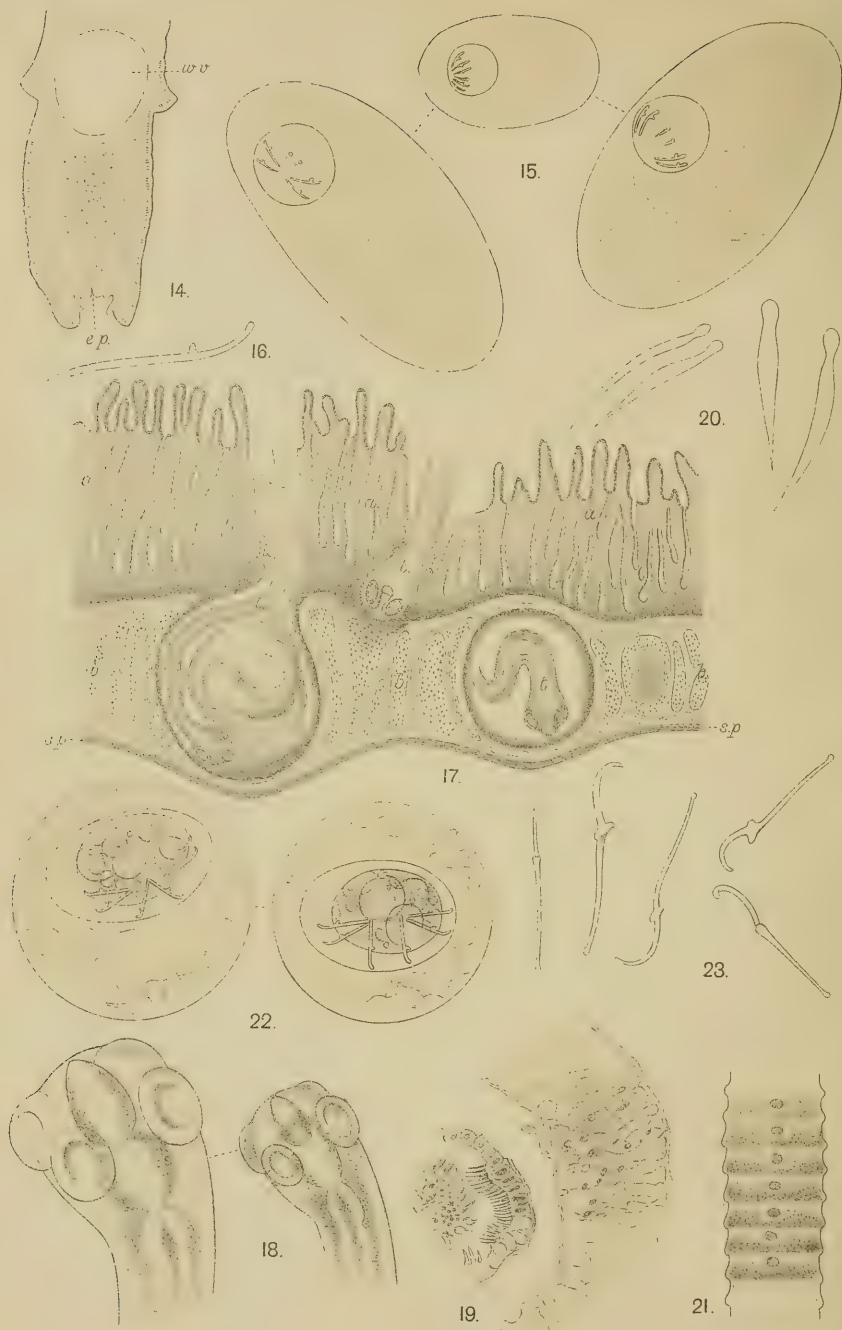


DAVAINEA UROGALLI AND HYMENOLEPIS MICRIPS. E. Wilson, Cambridge.



HYMENOLEPIS MICRIPS.





3. The Tape-Worms (*Cestoda*) of the Red Grouse (*Lagopus scoticus*). By A. E. SHIPLEY, M.A., Hon.D.Sc., F.R.S., F.Z.S., Fellow and Tutor of Christ's College, Cambridge, and Reader in Zoology in the University. With a Note by WM. BYGRAVE, M.A.

[Received December 18, 1908.]

(Plates LVI.—LX.)*

CESTODA.

Three species of tape-worm live in the alimentary canal of the Grouse. The largest of these is (i.) *Davainea urogalli* (Modeer), which lives in the small intestine (Pl. LVII. fig. 2). We have also from time to time found it in the cæca; its presence there is probably due to post-mortem migrations. This is the tape-worm known to the keepers and to sportsmen generally. It is large, sometimes a foot or more in length, and is occasionally seen protruding from the bird's anus and trailing through the air as the bird flies. The second and third tape-worms are inconspicuous and have hitherto escaped notice. One of them, (ii.) *Davainea cesticillus* (Molin), is small and very rare, we have only found it twice in the many hundreds of Grouse we have examined. It occurs, a few at a time, in the small intestine. The third tape-worm, (iii.) *Hymenolepis microps* (Diesing), is also inconspicuous, and so transparent when alive as almost to be invisible. It exists in hundreds in the duodenum, and probably causes a considerable amount of disease and death to the birds (Pl. LVII. fig. 4). It is by far the most dangerous of the three tape-worms of the Grouse.

(i.) Fam. Tæniidæ.

Genus DAVAINEA R. Bl. & Raill., 1891.

(i.) DAVAINEA UROGALLI (Modeer), 1790.

Synonyms: *Tænia urogalli* Modeer, 1790.

Tænia calva Baird, 1853.

Davainea calva Shipley, 1906.

The worm was apparently named *Tænia urogalli* by Modeer† in the year 1790. I am greatly indebted to Dr. O. Fuhrmann, of Neuchâtel, for pointing out that this tape-worm is identical with that described in 1853 by Baird and called by him *Tænia calva*.

The following is Baird's‡ description:—

"*Tænia calva* Baird, Cat. Entoz. Brit. Mus. 83.

"Head small, rounded and smooth, white and shining. Mouth unarmed. Neck constricted. Articulations of body at first very

* For explanation of the Plates see p. 362.

† Vet. Ac. Nya Handl. 1790, p. 129.

‡ Proc. Zool. Soc. Lond. xxi. 1853, p. 24.

small, gradually enlarging in breadth as they descend till they reach about the middle of the body, where they are still narrow, linear-shaped, and about seven times broader than long. After this they begin to increase in length and diminish in breadth, becoming at first nearly square, and at last, near the extremity, nearly twice as long as broad. All the articulations are strongly striated across, and the upper and lower margins, where they join with each other, are considerably thickened. Length $5\frac{1}{2}$ inches, greatest breadth $3\frac{1}{2}$ lines, breadth of lower extremity 1 millimetre, of head $\frac{1}{6}$ mm.

"*Hab.* Intestines of the common Grouse, *Lagopus scoticus*, Brit. Mus."

The same worm has been more fully described, also under the name *T. calva*, by F. S. Monticelli*.

The genus *Tenia* has been comparatively lately broken up into a number of other genera, and one genus *Davainea*, named after the celebrated French helminthologist Davaine, has been established for those worms which have the rostellum and suckers armed with a multitude of characteristically shaped hooks or thorns. The genus was made in 1891 by R. Blanchard and A. Railliet, and it comprises a number of species which, as a rule, live in the small intestines of birds.

Specimens of *Davainea urogalli* vary greatly in appearance and in size. On the whole, they have in life rather an untidy, dishevelled appearance, without clear-cut features; some preserved specimens, however, had very definite outlines. Doubtless much depended on the preservative.

Our longest specimens measured 35 cm. in length; the greatest breadth was 4 mm. The preserved material evidently died in very varying states of contraction, and it is difficult to make general statements as to the relative proportions of different parts of the body. One specimen 35 cm. in length we found in a bird of not more than three weeks old. It was shedding ripe proglottides. This worm had split and presented a forked tail, one limb of which, however, seemed to have dwindled and come to nothing.

The head is very small. Baird gives its breadth as " $\frac{1}{6}$ mm." I should put it at about the same, but here, as elsewhere, no two specimens are exactly alike. The proglottides which follow are extremely narrow from behind forward, but they very rapidly increase in breadth, so that 6 or 7 mm. from the head the breadth is 1 mm., and at about 12 to 15 mm. it is 2 mm. The greatest breadth is usually about 2.5 mm. to 3 mm., but in some specimens 4 mm. are reached (Pl. LVII. fig. 2). The broadest portion is usually about the third quarter of the body from the head; even here the segments still have but a very shallow antero-posterior diameter, about 0.6 mm. to 1 mm. Behind this region the segments narrow again. They become as long as they are broad,

* Boll. Soc. Napoli, ser. I. v. 1891, p. 155.

and but for the prominent posterior lip the segments would be square. The posterior segments are, however, longer than they are broad, and quite at the hinder end they are attached to one another by but a slender connection. The prominent posterior angle is maintained to the last. It is, however, difficult to give precise statements as to the condition of this worm. In some, one region of the body will be swollen out; in other specimens, other regions will expand. Some have a thin, papery consistence; others are plump and almost circular in section. Sometimes the posterior rim overlaps the anterior region of the succeeding segment, so that the whole resembles the pile of conical caps which clowns used—I do not know whether they still do so—to wear in the circus. These varying conditions doubtless depend largely on the state of the parasite when killed and on the means taken to kill them. The genital pore is, except in rare cases, on one end and the same side.

The anterior end tapers quickly to the very small, squarish head (Pls. LVI. & LIX. figs. 2 & 6). Anteriorly, the head ends in a rostellum, which seems nearly always to be retracted into a shallow recess. At each of its four corners the head bears a large sucker, as a rule circular, but at times oval in shape, and then the long axis is longitudinal.

Both rostellum and suckers bear hooks, which differ, however, both in their arrangement and shape. The hooks of the rostellum are arranged in a double row. Each is shaped something between a Y and a T (Pl. LIX. figs. 7 & 8), one arm being more curved than the other and it is this arm which is anterior. The stalk of the hook is but very slightly curved, and the posterior row alternates with the anterior. The length of the hooks is between $6.9\ \mu$ and $6.6\ \mu$. The shape of the hooks does not vary appreciably and the arrangement in two rings is very regular. These hooks were not seen by Baird and were first recognised in 1891*.

The hooks on the suckers are also very minute, and they vary considerably in size: the largest forms are about as long as the rostellar hooks, *i. e.* $6.6\ \mu$; the smallest forms are perhaps half this size, and there are intermediate sizes. Each hook is slightly curved and tapers to a fine point, each possesses a "heel" which, as is shown in fig. 10, Pl. LIX., is developed in varying degrees. In many cases the proximal end resembles the "head" of a thigh-bone. The hooks are arranged in a ring, but the ring contains no definite and regularly arranged rows, rather it is a small circular forest or hedge of hooks of varying sizes and shapes (Pl. LIX. fig. 9).

The head is usually followed by an unsegmented neck, three or four millimetres in length, but I have seen one or two specimens in which the segmentation occurs immediately behind the head. In transparent specimens longitudinal muscles running to the suckers can be seen traversing the neck. In most specimens the

* F. S. Monticelli, Boll. Soc. Napoli, ser. I. v. 1891, p. 155.

reproductive pore is on one side of the body throughout its entire length, but in others, and rarer, it changes over and having been for the anterior half of the body on the right side it suddenly passes to the left and remains there till the end.

The number of the proglottides varies with the length of the worm. An average-sized specimen would have between 250 and 400 proglottides; each of these might contain, say, a couple of hundred eggs. These figures, though necessarily rough, give some idea of the number of ova a single tape-worm may contain at any one moment. But mature proglottides are always breaking away and fresh ones are always being formed, like a recurring decimal, so that the number of ova a tape-worm produces in the course of its life is very much greater than the number it contains at any one moment.

Although the male and female reproductive openings are close together, the male orifice is very clearly anterior to that of the female. It leads into a muscular protrusible penis, which was in all cases retracted. The penis ends in a much coiled vas deferens which runs half across the proglottis near and slightly obliquely to the anterior edge; here it ends in a number of diverticula which form the testes. These are scattered through the parenchyma. The wall of the vas deferens is thin, its lumen is spacious, and it acts as a vesicula seminalis. The lumen is lined by a thin cuticle, and outside this and all around it are a number of spherical or oval cells which without exactly forming an epithelium probably secrete the cuticle.

The vagina opens immediately behind the vas deferens. Its outermost part is thick-walled and the lumen contains some homogeneous substance which stains deeply; further on the wall becomes thinner, the lumen more capacious, and here masses of spermatozoa are to be seen. The ovaries are two, right and left, each rather of a cauliflower shape; they contain rounded ova in which besides the nucleus a second deeply staining body is sometimes seen. The vagina makes a turn through about a right angle, and passing between the two ovaries, where it receives the two oviducts, it travels back to the vitellarium, a somewhat pyramidal body lying close to the posterior end of each proglottis. Certain unicellular glands in this region of the female duct are probably shell-glands.

There seems to be no walled uterus, but the fertilized ova are scattered throughout the body embedded in the parenchyma. Each is a large oval cell with very vacuolated protoplasm and a nucleus at one side and numerous yolk-granules (Pl. LIX. fig. 12).

Monticelli describes the proglottides as longitudinally striated, and the striations as due to the longitudinal muscles. These are certainly conspicuous in section, although in our specimens the external striation was not very well marked.

One striking feature of *D. urogalli* is the great extent to which the water vascular system is developed. It is spacious and large in the anterior segments, but in the posterior half of the body it

becomes very much larger. The lumen of the lateral canals increases and the transverse duct which unites them at the posterior end of each proglottis swells out amazingly. From being a slender duct it enlarges to a great spherical chamber, of which the sides, which will rupture when the proglottis drops off, are extremely thin (Pl. LIX. fig. 13 & Pl. LX. fig. 14).

When the ova are squeezed out of a living ripe proglottis of *D. urogalli*, they present the appearance shown in Pl. LIX. fig. 12. A more highly magnified view is shown in Pl. LX. fig. 15. Each egg contains a six-hooked embryo which is much smaller than the egg-shell. Besides the six-hooked embryo, the egg-shell contains two or three spherical bodies usually of about the same diameter as the embryo, but sometimes smaller. These are apparently yolk-spheres in course of absorption; the remainder of the egg-shell is empty. The six hooks, arranged in three pairs, have a characteristic shape shown best in Pl. LX. fig. 16. The shape is similar to that of the hooks figured in the sketches of *Davainea* embryos in Blanchard's article*.

The genus *Davainea* occurs in many birds, Cursores, Gallinaceæ, Columbinae, &c., and much more rarely, in the form of *Davainea madagascariensis* (Dav.), in the intestine of man. Little is known of their second hosts; they are usually believed to be insect larvæ, centipedes, or land mollusks. Grassi and Rovelli† consider the intermediate host of the *D. proglottina* of the common fowl to be *Limax cinereus*, *L. agrestis*, and *L. variegatus*. In this case the cysticeroid is fully developed in the slug within twenty days. If the slug be swallowed by a fowl the cysticeroid becomes adult at the end of eight days. We have up till now sought for the cystic form in *Limax flavus* without success.

Davainea echinohothrida‡, which is possibly a synonym of *D. tetragona*, causes a nodular disease in poultry§, a condition liable to be mistaken for tuberculosis. This disease was first recorded in the United States by Moore (1895)||, from whose article the following extracts are made:—

"The nodules were invariably more numerous in the lowest third of the small intestine. They occasionally appeared, however, in small numbers in both the duodenum and colon. The larger and to all appearances older nodules were found in the ileum near the cæca.

"In the badly affected portion the nodules gave the appearance of closely set protuberances, varying in size from barely perceptible areas of elevation to bodies 4 mm. ($\frac{1}{6}$ inch) in diameter. In some instances they appeared to overlap one another. When separated by a band of normal tissue they were round or somewhat lenticular in form. In the latter case the long diameter

* Mém. Soc. Zool. France, iv. 1891, p. 420.

† Centrbl. Bakter. iii. 1888, p. 172.

‡ B. H. Ransom, 'Manson's Eye Worm of Chicken, &c.,' Bureau of Animal Industry, U.S.A., Bulletin 60, 1904.

§ D. E. Salmon, 'Tapeworms of Poultry,' Bureau of Animal Industry, U.S.A., Bulletin 12, 1896.

|| V. A. Moore, Bureau of Animal Industry, U.S.A., Circular III., 1895.

was usually transverse to the long axis of the intestine. The larger nodules were of a pale dark-yellowish colour, while the smaller ones varied in shade from the more highly coloured areas to the neutral grey of the normal serosa. To the touch they gave the sensation that would be expected if the subserous and muscular coats were closely studded with small, oval, solid bodies. The mucosa presented similar elevations. Attached to the mucosa over the nodules were a number of tapeworms. There were also in the more advanced cases a variable number of small (0.5 to 1 mm.) areas over the larger nodules in which the mucosa had sloughed, leaving small ulcerated depressions.

"The larger nodules contained a greenish-yellow necrotic substance, which appeared in the advanced stages as a sequestrum with a roughened surface. On section it has a glistening, homogeneous appearance. Surrounding the necrotic substance was a thin layer of infiltrated tissue. The smaller nodules contained a more purulent-like substance and the smallest appeared to the naked eye as areas of infiltration. Sections of the affected intestine showed upon microscopic examination that the heads of the tape-worms had penetrated the mucous membrane and were situated in different layers of the intestinal wall (*cf.* Pl. LX. fig. 17). They were frequently observed between villi. As would be expected, the heads were not readily detected in the necrotic masses contained in the larger nodules, but were almost invariably seen in the smaller ones. In a few sections the tape-worm could be traced through the mucosa to the nodule in the muscular tissue in which its head appeared. In the earlier stage of the nodular development there is a cell infiltration about the head of the worm. This process continues until the infiltrated tissue reaches a considerable size.

"The worms attached to the mucosa were usually small. A larger form was commonly found in the intestinal contents. Although macroscopically they appeared to be different, Doctor Stiles found that they were presumably of the same species.

"*Economic Importance.*—The importance of this disease is much greater than it at first appears, as the close resemblance of the nodules to those of tuberculosis renders it of much significance from a differential standpoint. As the intestines are stated to be frequently the seat of the specific lesions of tuberculosis in fowls, it is of the greatest importance that a thorough examination be made before a positive diagnosis is pronounced. There are already several statements concerning the presence of tuberculosis in fowls in which the data given are not sufficient to differentiate the disease from the one here described. A somewhat analogous disease of sheep caused by a nematode (*Esophagostoma columbianum* Curtice) has led to the deliberate destruction of many animals, the owners believing that tuberculosis was being eliminated from their flocks.

"As the inquiry into the cause of poultry diseases becomes more general it is probable that this affection will be occasionally encountered, and unless its nature is recognized it may in some instances, like the sheep disease, lead to an unwarranted destruction of property.

"In addition to its importance in differentiating tuberculosis it is in itself a malady worthy of careful attention. The fact that it has already appeared in two flocks in the District of Columbia, and also in the States of North Carolina and Virginia, shows that the infesting cestode is quite widely distributed in this country. It is highly probable that the total loss it occasions, both from deaths and from the shrinkage of poultry products, due to the chronic course of the disease it produces, is very large."

(ii.) *DAVAINEA CESTICILLUS* (Molin), 1858.

Synonym: *Tenia cesticillus* (Molin).

This is a small species; the majority of our specimens measured between 5.5 and 9 mm. in length. Few were longer, though many were shorter. They were all young immature specimens. The broadest at their broadest part, usually about the level of the last proglottis but two or three, measured 1 mm. across. They tapered to the last proglottis, which averaged about 0.5 mm. in diameter, and still more do they taper towards the head, where the narrow neck is but 0.2 mm. The head itself is 0.3 to 0.5 mm. across and perhaps two-thirds of this in length.

The hooks in the rostellum were numerous, I should judge a few hundred, but I could not, on account of their minute size, count accurately: they measured about 7 μ in length.

The head when the rostellum is withdrawn is somewhat cup-shaped and the four suckers are on the edge of the cup, opening at the edge and slightly inwards. There is practically no "neck," just a constriction between the head and the first proglottis. Behind the head the proglottides increase markedly in size, and the third proglottis in most specimens is already as broad as the head. They are deeply imbricated and the overlapping edge is full and rounded. At the level of the anterior end of each proglottis is a constriction which slightly separates off the overlapping lobe from the preceding proglottis, to which it, of course, belongs. This gives a somewhat ear-like outline to the side of each segment. The constriction first appears in about the tenth proglottis, and the characteristic outline is lost in the last, where the overlapping edges curve in as if to guard the excretory opening. The total number of the proglottides varies a little with the variable length, but differences in length depended far more on the state of contraction of the body than on the number of segments. Roughly speaking, the numbers varied from about eighteen to about twenty-eight proglottides.

The genital pore is alternate and fairly regularly so; the penis often projects, and then it is apparent that the pore lies rather anteriorly and is all but overlapped by the imbricated edges of the proglottis next in front.

Sections show that there are a number of calcareous bodies in the tissues; some of these are in optical section brick-shaped, and others spherical or shaped like a cottage-loaf. These latter are bigger than the others and show numerous radiating lines. Posteriorly the tissue becomes very highly vacuolated and the embryos lie in small packets which do not seem to be in a uterus, and may be, as Morell suggests in *D. urogalli*, in the lumen of the ovary itself.

This tape-worm, common in chickens and turkeys, is only an occasional parasite of the grouse, and has in many hundreds of birds we have examined only been found twice, and in neither case has its presence been associated with any lesions. As a factor in grouse-disease it may be neglected. In both cases only young, immature, not fully grown specimens were met with. Its second host is according to Railliet, quoting Grassi and Rovelli, probably some Coleopteran or Lepidopteran, but at present this has not been proved.

HYMENOLEPIS Weinland, 1858.

(iii.) *HYMENOLEPIS MICROPS* (Diesing), 1850.

Synonyms: *Tænia microps* (Diesing), 1850.

Hymenolepis tetraonis (Wolffh.), 1900*.

This is an extremely delicate, transparent tape-worm which exists in almost countless numbers in the duodenum of *Lagopus scoticus*. It is also recorded from the Blackcock and the Capercaillie. On cutting open the duodenum of a grouse infested with these worms—and we have rarely found a bird free from them except in the winter months—they are not at first apparent. They are so fine and so transparent that they are practically invisible when alive, and the contents of this part of the alimentary canal appears very much like a thick purée. If we add to this some fixing agent such as corrosive sublimate this purée resolves itself into a mass of very fine, delicate, white threads inextricably tangled up together and so numerous that there seems but little room left in the duodenum for the passage of the food (Pl. LVIII. fig. 3). If, with great care—for they break at the slightest strain—we succeed in disentangling one of these worms we shall find its head embedded to a greater or less extent in the mucous lining of the duodenum, into which, to use a poetic phrase, “it nuzzles” whilst the body of the worm floats freely in the fluid contents of this part of the alimentary canal. If we also succeed in freeing the head we now have a complete worm and can study its structure.

* Wolffhügel, K., “Beitrag zur Kenntniss der Vogelhelminthen,” Inaug.-Diss., Freiburg-i.-B. 1900.

Before giving some anatomical details of *H. microps* it is worth mentioning that Wolffhügel found fragments of this species—none with the head—in the small intestine, large intestine, and end—he does not say which end—of the cæca of *Tetrao urogallus*. We have also found short chains of ripe proglottides passing down the alimentary canal on their way to the exterior, but the tape-worm as an individual lives only in the duodenum.

H. microps is a very long worm, attaining in the longest examples a length of some 15–16 cms. It consists of an enormous number of proglottides. The first two millimetres which come after the head contain as many as 60–70 segments, and lower down the body, where the proglottides were mature, as many as 10 proglottides measured but 1 mm. Of course these measurements depend entirely on the state of the contraction of the worm, but if we take the mean between them as a rough average approximation we shall get the astonishing number of 3000 proglottides in a single specimen. As each proglottis contains a large number of eggs and as they are being continually renewed, and as, further, the number of tape-worms in the duodenum amounts to hundreds, it is easy to see that a grouse-moor must be just peppered over with ova (Pl. LVII. fig. 4).

The head is somewhat squarish (Pl. LX. fig. 18), with a central retractile rostellum and four suckers at the corners. The rostellum is surrounded by a closely packed ring of very numerous spines or hooks (Pl. LX. figs. 19 & 20). These are very minute and, except in the fresh specimen, very difficult to see, and even then it requires an immersion-lens to make out anything of their structure. Their proximal end is rounded, and then comes a constriction; the spine then thickens till about the middle of its length and then tapers to a very fine point. Although these spines are slightly curved, they are in no sense hooked (Pl. LX. fig. 20). I have tried to measure the length of these spines from specimens of the head, which has been cut in sections. I am not quite sure that the hooks were entire, and so am not quite sure that my measurement is large enough, but I should put their length at about 16 μ —certainly not less. The hooks seem to be in a single row, but very close together.

The suckers are deep and well marked, but it must always be borne in mind how very small the head is, and corresponding with this the suckers are also very minute.

The posterior edge of each proglottis is “saillant,” but it does not overhang the succeeding proglottis; it stands out like the tooth of a saw, and viewed laterally the side of this worm is very saw-like. Throughout the body the proglottides are much broader than they are long. In the older ones there are numerous calcareous bodies, the measurements of which Wolffhügel gives as 0.018 mm. by 0.01 mm. (Pl. LX. fig. 21).

The genital pore is in all the segments on the same side; the left, judging by the orientation suggested by the female reproductive organs, being on the ventral surface. The vagina opens

into a peculiarly large and muscular receptaculum seminis, which runs across the proglottis and then turns backward; in some preparations this turn is seen "en face" and then the radiating muscles give the appearance of a ring of very fine spines, and, indeed, at first I thought that there was such a ring, but I believe the above is the true explanation. There are three testes the vasa deferentia of which unite and after entering the cirrus-bulb enlarge to form a vesicula seminalis. The vagina opens ventral to the penis. The uterus is a single chamber unbranched. It forms a conspicuous feature in the hinder end of stained specimens. At first it appears as a spherical organ lying in the middle line at the hinder end of each proglottis, but as it grows and absorbs more of the parenchyma it tends to become triangular or square, but always with very rounded angles. It contains a large number of relatively large onchospheres or tape-worm embryos (Pl. LX. fig. 22). According to Wolffhügel, the embryos measure 0.02 mm. in breadth by 0.04 mm. in length. The typical six embryonic hooks are very characteristic. The partners in each pair, for instance, are usually widely divaricated; their length is 0.014 mm. These characteristic *Hymenolepis* ova have three envelopes: the innermost, closely applied to the embryo, is never produced into horns; between it and the middle envelope is only a clear fluid in which the embryo floats; between the middle and the outer envelope are the much vacuolated remains of cells. The position of the embryo is eccentric with regard to this outer shell (Pl. LX. fig. 22), which measures 0.073 mm. by 0.066 mm. The measurements are again Wolffhügel's. The characteristic hooks are figured on Pl. LX. fig. 23.

We have no information about the fate of these embryos, but as a general rule the cystic form of this genus lives in some Insect or Myriapod, as is shown by the fact that this genus of tape-worm occurs in Bats, Insectivores, Rodents, and Insectivorous birds. *Hymenolepis nana* occurs in man, most frequently in children, and is not at all uncommon in Italy. Sporadic cases of *H. diminuta* occurring in man are also recorded.

We have made and we are making laborious investigations to try and discover this second host. In searching for the cysts of the Tape-worms we began with the insects which occurred most commonly in the crop of the grouse. These we examined microscopically, both after teasing the body up in glycerine and by grinding it up—but not too finely—in a pestle; in some cases also, as Mr. Fryer* has recorded, sections were made and examined, but always without result.

We were at two disadvantages in hunting for the cysts: firstly, we did not know what the cysts of either *Davainea urogalli* or *Hymenolepis microps* were like; and, secondly, the tissues

* Interim Report of the Grouse Disease Inquiry.

of the insects and spiders which we examined are little, if at all, known, and more than once we have at first sight taken some organ proper to the insect for a cestode cyst, only to our great disappointment to discover later that we were looking at an ovum or other structure belonging to the putative host.

During some days Dr. Wilson and I spent in Edinburgh towards the end of July, 1908, we examined a considerable number of the commoner insects found on the moors in the hope of throwing some light upon the life-history of the tape-worms so common in the grouse. The specimens we investigated were collected by Mr. P. H. Grimshaw, who is preparing a Report on the Insects of the Moors. We are greatly indebted to him and to the Keeper of the Museum, Mr. W. Eagle Clarke, and to Mr. J. Ritchie for kindly placing at our disposal a work-room and other accommodation which greatly facilitated our work. When the insect had not been specifically named we always kept a similar specimen for subsequent identification in case it should contain the cyst; but, alas! here again our labour was in vain.

In the manner indicated we examined the following Insects, in every case looking through the débris of some four or five specimens.

DIPTERA.

(i.) *Monophilus ater*, one of the subfamily Limnobiinæ of the Tipulidæ. A very common constituent of the food of young grouse. No trace of a cyst was found, but in one specimen an immature nematode was wriggling about.

(ii.) *Bibio* sp. Here again we drew a blank.

(iii.) *Cyrtoma spuria*, one of the Empidæ. This fly is small and seemed to have little interior; no trace of a cyst was found. In another small Empid fly we discovered a Gregarine.

(iv.) *Scatophaga* sp. *Scatophaga stercoraria* is perhaps the commonest fly in Scotland, and, owing to the larva living in the droppings of the grouse, it can hardly fail to contain the eggs of the cestodes; but we have never found a *Scatophaga* in the crop of a grouse, and there is some reason to doubt if the tape-worm eggs develop in this fly. After searching for a long time through the tissues of many specimens of *Scatophaga*, we only managed to find one ovum, apparently of *Davainea urogalli*, and that was no further advanced than when it was laid.

PLECOPTERA.

Similar gropings through the dissected membranes of an unknown species of Perlid produced no better results.

ARACHNIDA.

We also investigated the tissues of a spider very common on the moors, and of a phalangid, with an equal want of success.

NOTE BY WM. BYGRAVE, M.A., ON THE SEARCH FOR CYSTS.

Since September 1908 I have been making a series of investigations in connexion with the Grouse-Disease Inquiry. My work has consisted of a careful examination of the tissues of certain insects found on Grouse-moors in various parts of England and Scotland, the object being to discover, if possible, cysts of the three species of tapeworm which infest the grouse, viz. :—

Davainea urogalli (Modeer, 1790).

Davainea cesticillus (Molin, 1858).

Hymenolepis microps (Diesing, 1850).

The insects examined to date are specimens of *Scatophaga squalida* from Ballindalloch, and *S. stercoraria* from Burley, Dunachton, and Forrigen.

The specimens were sent to me by Mr. P. H. Grimshaw, from the Royal Scottish Museum, Edinburgh, preserved in spirit.

The method of examination was as follows :—

The legs and head were removed and the body of the insect teased up in 70 per cent. alcohol as finely as possible with needles, the legs and head being firstly teased and then gently pounded in a mortar.

The material thus obtained was examined under a cover-glass, a mechanical stage being used to ensure that none of the material was overlooked. The powers used were Leitz Obj. $\frac{1}{4}$ " and $\frac{1}{6}$ " Oc. 2 and 4; an oil immersion-lens being used in cases of doubt. So far the examination has yielded no results. Nothing has been found which in any way resembled the cysts, one or two of which have been figured, of species allied to the three tape-worms mentioned above.

EXPLANATION OF THE PLATES.

PLATE LVI.

- Fig. 1. View of a portion of the small intestine of the grouse well infested with *Davainea urogalli* (Modeer) and cut open to show the worms.

PLATE LVII.

- Fig. 2. A single specimen of *D. urogalli*, isolated to show the attenuated head.
4. A single specimen of *Hymenolepis microps*, isolated.
(The figures 2 and 4 are very slightly magnified.)

PLATE LVIII.

- Fig. 3. View of a portion of the duodenum of the grouse, well infested with *Hymenolepis microps* (Diesing), cut open to show the worms.

PLATE LIX.

- Fig. 5. Head of *D. urogalli* with proboscis half-exserted and armed suckers.
6. The same, with the proboscis completely retracted. This specimen shows the calcareous bodies well.
7. Portion of the double circle of hooks from the proboscis of *D. urogalli*.
8. Isolated hooks from the same, showing slight modification in outlines.
9. Portion of the ring of hooks which surrounds one of the suckers of *D. urogalli*, showing the irregular arrangement of the hooks.
10. Isolated hooks from the same, showing slight modification in outline.

- Fig. 11. Magnified view of mature proglottis of *D. urogalli*. *gp.*, genital pore; *ov.*, ovary; *p.*, penis; *t.*, testes; *v.*, vagina; *vit.*, vitellarium; *w.v.*, excretory system.
12. Ova of *D. urogalli*, showing the ovum and yolk-vesicles.
13. Longitudinal horizontal section through the same, showing the great extension of the excretory transverse canals, and the ova scattered in egg-capsules.

PLATE LX.

- Fig. 14. A similar section through the last proglottis, showing the enormous transverse canal at the level of the breaking zone and the excretory pore *e.p.*
15. Ova of *D. urogalli* more advanced than those shown in fig. 12, showing the onchosphere and traces of the yolk-vesicles.
16. An isolated hook from the same.
17. Transverse section of the walls of intestine of a fowl, showing *Tania botriopliti* embedded in the deeper layers of the intestinal wall. *aa.*, intestinal mucosa; *b.*, muscular layers; *sp.*, peritoneal lining; *tt.*, anterior ends of the tape-worms; *e.*, mass of exudate produced by the irritation of the head of the *Tania*. (From Piana, Mem. Ac. Sci. Istit. Bologna, series 4, vol. ii. 1880, p. 387.)
18. Head of *Hymenolepis microps* (Diesing), highly magnified.
19. Section through the retracted proboscis of the same, highly magnified to show the arrangement of the hooks.
20. Isolated hooks of the same seen under $\frac{1}{2}$ oil immersion-lens.
21. A few mature proglottides of the same, taken from about the middle of the body.
22. Onchospheres of *H. microps* in the characteristic three envelopes.
23. Hooks from the same.

4. Internal Parasites of Birds allied to the Grouse. By
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[Received December 18, 1908.]

The following is a brief enumeration of the Cestode, Trematode, and Nematode parasites of the Grouse, the Ptarmigan, the Blackcock, and the Capercaillie. To these I have added the Willow-grouse and the Hazel-hen, although these birds, unlike the three former, are not denizens of the British Isles. It will be noticed that but two Nematodes, *Trichosoma longicolle* (Rud.) and *Heterakis papillosa* (Bloch), and two Cestodes, *Davainea urogalli* and *Hymenolepis microps*, are common to our grouse and to its allies. The first named round worm and the tapé-worm are found in all three, Blackcock, Capercaillie, and Grouse, and in none of the other nearly allied birds; whilst *Heterakis papillosa* has been recorded from the Ptarmigan, the Capercaillie, the Hazel-hen and the Grouse, besides from many other birds.

Heterakis perspicillum (Rud.) also occurs in three hosts, in the Blackcock, the Hazel-hen, and the Capercaillie. All the other Nematode parasites mentioned occur in a single host, except *Heterakis compar* (Schrank) which is found in both the Ptarmigan and the Capercaillie. Of the Cestodes, *Davainea urogalli* and *Hymenolepis microps* occur in the Grouse, the Blackgame, and the Capercaillie.

I. LAGOPUS MUTUS Leach, or L. ALPINUS. The Ptarmigan.

The Ptarmigan contains *Heterakis* (*Ascaris*) *compar* (Schränk), *Heterakis papillosa* (Bloch), and *Heterakis borealis* (v. Linstow), amongst the Nematodes, and *Tenia echinata* amongst the Cestodes.

NEMATODA.

(i) *Heterakis compar* (Schränk).*

Synonyms. *Ascaris compar* Schränk 1790.

Ascaris lagopodis Fröhlich 1802.

Fusaria compar Zeder 1803.

Heterakis compar Stossich 1888.

A thin, white Nematode, the females of which attain a length of 84–96 mm., and the males a length of 36–48 mm., found in small intestine of the Ptarmigan, the Capercaillie, and other gallinaceous birds.

(ii) *Heterakis papillosa* (Bloch).

Synonyms. *Ascaris papillosa* Bloch 1872, nec Molin 1860.

Ascaris vesicularis Fröhlich 1791 *pro parte*.

Heterakis vesicularis Duj. 1845.

Heterakis papillosa Railliet 1885.

The male measures 7–13 mm., the female 10–15 mm. A very common parasite of the cæca of the alimentary canal. Sometimes it exists in prodigious numbers, causing a fatal perityphlitis amongst chickens.

This parasite is common in domestic fowls, ducks, geese, turkeys, peacocks, guinea-fowls, pheasants, etc., and occurs in the Ptarmigan, the Capercaillie, and the Hazel-hen (*Bonasia sylvestris*). The eggs of *H. papillosa* complete their development in water.

(iii) *Heterakis borealis* (v. Linstow).

Very little is known about this nematode, which was described in 1884 by von Linstow in the 'Archiv für Naturgeschichte,' l. (i.) p. 131.

CESTODA.

(i) *Tenia echinata* (Olss.).†

II. LAGOPUS ALBUS, or L. SUBALPINUS, or L. SALICETI. The Willow-grouse. I can find no record of any parasites being recorded from the Willow-grouse.

* Where possible the nomenclature follows that of Railliet in his "Zoologie Médicale et Agricole."

† Olsson, "Bidrag til Skandinav. Helminthfauna," ii., Stockholm, 1893.

III. *BONASIA SYLVESTRIS*. The Hazel-hen.*Tetrao bonasia* Linn.

NEMATODA.

(i) *Heterakis papillosa* (Bloch).v. under *Lagopus mutus*, p. 364.(ii) *Heterakis perspicillum* (Rud.).Synonyms. *Ascaris gallopavonis* Gmelin 1789.*Fusaria reflexa* Zeder 1800 *pro parte*.*Fusaria strumosa* Zeder 1800.*Ascaris perspicillum* Rud. 1803.*Ascaris gibbosa* Rud. 1809.*Ascaris inflexa* Rud. 1819 *pro parte*.*Ascaris funiculus* E. Deslongchamps 1824.*Heterakis inflexa* Schneider 1866.

Under the last synonym this worm has recently been recorded from the alimentary canal of a Russian Hazel-hen by Wolffhügel*. The males measure 3-8 cms., the females 6-12 cms. The worm is common in fowls, guinea-fowls, and turkeys, and gives rise to severe epizootics amongst poultry. Occasionally they are found free in the body-cavity, and sometimes occur in eggs, having made their way into the ovum before the shell is deposited.

(iii) *Filaria bonasice* (v. Nordmann).

This form apparently has been seen but once. It was found by v. Nordmann in the posterior chamber of the damaged eyes of a Hazel-hen taken in the island Wikari.

CESTODA.

(i) *Tenia bonasice* (Müller).

This tape-worm is recorded from the intestines, but practically nothing is known about it.

IV. *TETRAO TETRIX* L. Blackcock.

NEMATODA.

(i) *Trichosoma longicolle* (Rud.).

This is the worm (or one of them, more than one species may be included in Rudolphi's original description) described by Rudolphi. It occurs in the fowl, pheasant, and grouse as well as in blackgame, v. p. 345.

(ii) *Heterakis compar* (Schränk).†

v. p. 364.

* "Beitrag zur Kenntniss der Vogelhelminthen," Inaug.-Diss., Freiburg i. B., 1900.

† Müller, Arch. Naturg. 1897, p. 10, and Stossich, "Glasnik. Naravosl. druzt." 1887, p. 287.

(iii) *Heterakis perspicillum* (Rud.).*

v. p. 365.

(iv) *Heterakis magnopapilla* (v. Linstow).†

(v) *Strongylus papillatus* (v. Linstow).‡

Wolffhügel found both males and females in great numbers in the alimentary canal of the Blackcock. It had previously been described by v. Linstow from the intestine of the Great Bustard, *Otis tarda*.

(vi) *Strongylus hastatus* (v. Linstow).§

(vii) Nematode ? genus, recorded by Wolffhügel from the cæca.

TREMATODA.

(i) *Lyperosomum corrigia* (Braun).||

A fluke nearly allied to *Distomum plesiosomum* (v. Linstow, 1883) from *Perdix græca*.

CESTODA.

(i) *Davainea retusa* (Clerc).¶

(ii) *Davainea urogalli* (Modeer).

Described by Krabbe from specimens in *Perdix græca*, *Megaloperdix nigelli*, *Tetrao urogallus* and *T. tetrix*.

(iii) *Davainea villosa* (Bloch).

Also found in a *Megaloperdix nigelli* in Turkestan.

(iv) *Hymenolepis microps* (Diesing).**

This species, described by Wolffhügel under the name of *H. tetraonis* from a few fragments, is more fully described by me from *Lagopus scoticus* in the anatomical part of this memoir, cf. p. 358.

ACANTHOCEPHALA.

(i) *Echinorhynchus stellaris* (Molin).

Usually found in the Duck, but Dr. von Linstow tells me he has seen it in the larval stage encysted on the outside wall of the intestine in the Blackcock.

* "Glasnik. Naravosl. druzt." (Societas historico-naturalis Croatica), Zagreb, 1887, p. 278.

† "Schr. Ges." Königsb. xlvii. 1906, p. 112.

‡ Arch. Naturg., 1882 (i), p. 3.

§ Ibid., 1905, p. 274.

|| Centrbl. Bakter. xxix. 1901, p. 946.

¶ Rev. Suisse Zool., xi. 1903, p. 363.

** "Beitrag zur Kenntniss der Vogelhelminthen," Freiburg i. B., 1900.

V. TETRAO UROGALLUS L. The Capercaillie.

NEMATODA.

- (i) *Heterakis compar* (Schränk), v. p. 364.
- (ii) *Heterakis papillosa* (Bloch), v. p. 364.
- (iii) *Heterakis perspicillum* (Rud.), v. p. 365.
- (iv) *Filaria urogalli* (v. Linstow).
Lives in the subcutaneous tissues.
- (v) *Trichosoma longicollis* (Rud.), v. p. 345.

CESTODA.

- (i) *Bothriocephalus* sp.

Cobbold* found in the subcutaneous tissue lying over the pectoral muscles of a Capercaillie a single specimen of a tape-worm which he compared with a *Ligula reptans*. It was probably a larval *Bothriocephalus*.

- (ii) *Davainea urogalli* (Modeer), v. p. 351.
- (iii) *Davainea globocaudata* (Cohn).†
- (iv) *Hymenolepis microps* (Diesing).

LIST OF PARASITES WITH THEIR HOSTS.

NEMATODA.	HOST.
<i>Filaria bonasia</i> (v. Nordm.) ...	<i>Bonasia sylvestris</i> .
<i>Filaria urogalli</i> (v. Lins.)	<i>Tetrao urogallus</i> .
<i>Filaria</i> sp.	<i>Lagopus scoticus</i> .
<i>Heterakis borealis</i> (v. Lins.) ...	<i>Lagopus mutus</i> .
<i>Heterakis compar</i> (Schränk) ...	<i>Lagopus mutus</i> , <i>Tetrao tetrax</i> , and <i>Tetrao urogallus</i> .
<i>Heterakis papillosa</i> (Bloch).....	<i>Lagopus mutus</i> , <i>Lagopus scoticus</i> , <i>Tetrao urogallus</i> , and <i>Bonasia sylvestris</i> .
<i>Heterakis perspicillum</i> (Rud.)...	<i>Tetrao tetrax</i> , <i>Tetrao urogallus</i> , and <i>Bonasia sylvestris</i> .
<i>Heterakis magnopapilla</i> (v. Lins.)	<i>Tetrao tetrax</i> .
<i>Strongylus papillatus</i> (v. Lins.)	<i>Tetrao tetrax</i> .
<i>Strongylus hastatus</i> (v. Lins.)...	<i>Tetrao tetrax</i> .
<i>Syngamus trachealis</i> (v. Sieb.)	<i>Lagopus scoticus</i> .
<i>Trichosoma longicollis</i> (Rud.) ...	<i>Tetrao tetrax</i> , <i>Tetrao urogallus</i> , and <i>Lagopus scoticus</i> .
<i>Trichostrongylus pergracilis</i> (Cobb.)	<i>Lagopus scoticus</i> .
Nematode gen.....	<i>Tetrao tetrax</i> .

* Tr. Linn. Soc. London, xxii. p. 165.

† Zool. Anz. xxiii. 1900, p. 91, and Acta Ac. German. lxxix. 1901, p. 263.

HOST.

Lyperosomum corrigia (Braun) *Tetrao tetrix*.

CESTODA.

<i>Bothriocephalus</i> sp.	<i>Tetrao urogallus</i> .
<i>Davainea cesticillus</i> (Molin) ...	<i>Lagopus scoticus</i> .
<i>Davainea globocaudatus</i> (Cohn)	<i>Tetrao urogallus</i> .
<i>Davainea retusa</i> (Clerc)	<i>Tetrao tetrix</i> .
<i>Davainea urogalli</i> (Modeer) ...	<i>Tetrao tetrix</i> , <i>Tetrao urogallus</i> , and <i>Lagopus scoticus</i> .
<i>Davainea villosa</i> (Bloch)	<i>Tetrao tetrix</i> .
<i>Hymenolepis microps</i> (Diesing)	<i>Tetrao tetrix</i> , <i>Tetrao urogallus</i> , and <i>Lagopus scoticus</i> .
<i>Tenia bonasice</i> (Müll.)	<i>Bonasia sylvestris</i> .
<i>Tenia echinata</i> (Olss.)	<i>Lagopus mutus</i> .

ACANTHOCEPHALA.

Echinorhynchus stellaris (Molin) *Tetrao tetrix*.

5. On a Fossil Bird from the Lower Pliocene.

By W. P. PYCRAFT, F.Z.S., A.L.S.*

[Received February 16, 1909.]

(Text-figure 47.)

The following account concerns the fossilized remains of a small Passerine bird from the Lower Pliocene of Gabbro, near Leghorn. The slab in which these remains are embedded was placed in my hands for investigation by my friend Dr. Forsyth Major, F.R.S., who has, throughout my enquiry, rendered me much help.

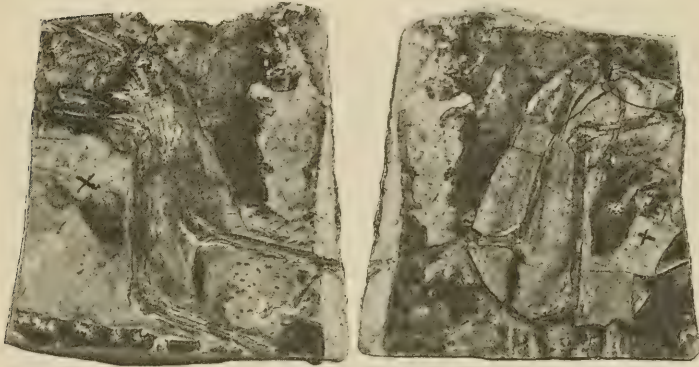
Unfortunately, only the pelvic limbs and a few traces of feathers are here preserved; further, the bones are much crushed, and the phalanges have been almost entirely lost. But from the slab and its counterpart, which has happily been preserved, sufficient details may be gathered to make identification possible.

The right leg lacks the toes. The femur, on the slab, is much crushed and can only very imperfectly be traced; but on the counterpart of the slab it becomes clear that it is seen from its dorsal aspect, since the middle of the shaft shows a smooth, periosteal, surface; while the extremities thereof are missing, leaving beautiful impressions of the distal and proximal articular ends. The tibio-tarsus is seen from its fibular side. Herein traces are visible of the head of the fibula, closely approximated to the femoral trochlea, and of the external border of the ectocnemial

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crest. The fibular crest has been crushed. The distal end of the shaft, though crushed, shows the form of the trochlea. On the counterpart the proximal extremity of the shaft is much damaged; while of the distal end only an impression remains.

Text-fig. 47.



The Slab (left-hand figure) and the counterpart thereof (right-hand figure) containing remains of a fossil Pipit (*Anthus bosniaskii*).

The hind-toe of the left leg is clearly seen in the Slab, while to the left of the tibial shaft of the right leg traces of feathers are preserved (marked X), but these are much more clearly seen on the counterpart.

The left leg is more complete, but lacks the front toes. On the slab the femur is seen from its ventral aspect; the head is missing, but the condyles of the distal extremity can be fairly well made out. The tibio-tarsus is seen from its inner aspect. It is therefore somewhat curious to find that the fibula has become detached from the fibular crest, and lies with its head in close juxtaposition to the fibular condyle of the femur, as may be seen in the photograph (text-fig. 47). The entocnemial crest is fairly well preserved. The counterpart of this slab lacks the proximal extremity of the tibio-tarsus, owing to the flaking away of the matrix, while the distal end of the shaft can only very indistinctly be made out. The tarso-metatarsus, though preserved in its entirety, is too much crushed at its proximal extremity to make it possible to distinguish the mesotarsal articulation. The shaft is also flattened and crushed. The ecto- and entocnemial trochleæ can be made out, but the mesotrochlea is obliterated.

Of the digits only the hallux is preserved, but the metatarsal thereof cannot be traced, while the ungual phalanx is much crushed and flattened. This digit, however, serves at once to show the Passerine character of these remains, and this because of the great length of the proximal phalanx and its position in regard to the other toes. Of the other digits only fragments of

the proximal phalanges remain. The only trace of the tarso-metatarsus and hallux, which is preserved in the counterpart, takes the form of a very shallow depression in the matrix, showing that an overlying flake of stone and the bone imbedded therein have been lost.

There is a cluster of fragments of other bones in this slab, and these appear, at first sight, to be portions of thoracic vertebræ—crushed centra and neural spines. A closer examination shows that these “spines” are too high to belong to the vertebral column of any Passerine bird of this size.

And now a word as to the traces of feathers which are to be found on the slab and counterpart containing the bones just described. These impressions occur in the form of a large patch occupying the middle of the area shut in by the femur and the shank of the left leg. On the slab a portion of this patch has been lost, but in the counterpart it is complete, and indicates a mass of feathers, probably of the flanks, matted together as if by wet. They show, moreover, that these remains must have been exposed to the action of tides, where low water would leave the feathers in a matted “draggled” condition. Before finally covered by the next high tide they must have become effectually covered by mud; and this because feathers under water would float out, much as in life.

Along the lower end of the “shank” of each leg there are also impressions of feathers, which cease at the mesotarsal articulation.

SUMMARY.

There seems little room for doubt but that the remains just described are those of a Pipit (*Anthus*); at any rate, they agree more closely with bones of this genus than with those of any other group of Passerine birds with which I have compared them. And among the members of this genus these remains resemble most nearly those of the living species known as Berthelot's Pipit (*Anthus bertheloti*).

In the shape of the condyles of the distal end of the femur, and of the trochleæ of the distal extremity of the tarso-metatarsus, slight differences are discernible when the fossil remains and the skeletons used for the purposes of comparison in this paper are compared. But these differences are very slight, and they may be due to pressure.

Assuming that I am correct in ascribing these remains to an extinct species of the genus *Anthus*, I propose to adopt the name of the discoverer—Dr. Bosniaski—as the specific name. *Anthus bosniaskii* was obtained by Dr. Bosniaski from the Lower Pliocene of Gabbro near Leghorn, a deposit which has yielded many fossils and which is particularly rich in fish-remains.

So far as I can make out, the only other remains of Passerine birds from the Lower Pliocene are a few fragments representing the genera *Corvus* and *Turdus* from Rousillon, Perpignan.

6. On a Collection of Mammals from Western Java presented to the National Museum by Mr. W. E. Balston. By OLDFIELD THOMAS, F.R.S., F.Z.S., and R. C. WROUGHTON, F.Z.S.*

[Received February 27, 1909.]

Up to and during the earlier part of the last century no tropical country in the world had more attention paid to its zoology than the Island of Java, quite a considerable number of species being described from there, firstly by the French, who received specimens from Diard and Duvaucel, then by Dr. Thomas Horsfield, who in 1824, under the auspices of the East India Company, published a special work † on the subject, and finally by the Dutch authors Schlegel and Müller, who included many Javan animals in their general work ‡ on the Mammals of the East Indian Archipelago (1839-44).

But from the latter date to the present time almost nothing has been done, and but few specimens have been collected except those that have gone to Leyden; and workers in the other principal Museums have been often embarrassed by the absence of good Javan specimens, representing the early described species, for comparison with examples from other localities.

Of late, in the working out of Bornean and other Malay material, the want of Javan collections has been severely felt, and we are therefore proportionately indebted to Mr. W. E. Balston for enabling the well-known collector Mr. G. C. Shortridge to make a collecting-trip to Java after he had finished the work in Western Australia of which Thomas had previously given an account in our 'Proceedings.'

Mr. Shortridge found the island extremely favourable for collecting, and by the kind assistance of Mr. M. C. Kirkpatrick, of the Hongkong and Shanghai Bank, and of the local Museum authorities, he was enabled to visit many interesting localities and to make one of the finest collections that we have ever received from any one region.

In all, Mr. Shortridge obtained over 1500 specimens in the island, the majority of which, however, were Bats, a group in which Java is astonishingly rich. The species number 74, of which we have found it necessary to describe six as new. In addition, good series were obtained of a large number of species which were either not in the Museum collections at all, or else only represented by specimens from Dr. Horsfield's collection, which had been first to the East India Company's Museum and then transferred, mostly in 1879, to the British Museum. These, while of extreme value as types or historical specimens, are

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† 'Zoological Researches in Java,' 1824.

‡ In Temminck's 'Verhandelingen over de Natuurlijke Geschiedenis der Nederlandsche overzeesche bezittingen,' 1839-44.

mostly too faded and deteriorated to be of much practical use in making comparisons.

For the present magnificent addition to the National Collection we have every reason to be most grateful to Mr. Balston, to whom we were already so heavily indebted for his W. Australian donations.

We have appended to the species Mr. Shortridge's notes on their habits, native names, and distribution.

1. HYLOBATES LEUCISCUS Schreb.

♂. 492. ♀. 486, 487. Tji Wangie, Preanger.

“ ‘Ooa-ōōa’ (Soendanese). ‘Wau-wāu’ (Malay).

“Local, apparently confined to the mountains of West Java; where it occurs its presence is easily detected by its continuous cry, which carries a long distance and of which its native name is an imitation.”—G. C. S.

2. PRESBYTIS PYRRHA Horsf.

Semnopithecus vel *Presbytis maurus* auctorum, nec Schreber.

♂. 1793. ♀. 1707 imm., 1709 imm., 1734 imm. Pangandaran, Dirk de Vries Bay.

♂. 614. ♀. 615, 616 imm., 617 imm., 749, 787, 788 imm. Tjilatjap.

♂. 475, 493. ♀. 474, 479, 480. Tji Wangie, Preanger.

♀. 1521 imm., 1524 imm. Kalipoetjang, Tji-Tandoei River.

A comparison of this fine series, all black specimens, with the co-types of Horsfield's "*Semnopithecus pyrrhus*" does not confirm the conclusions as to the specific distinctness of the black and red forms of the group published by Dr. Jentink*. The skull of No. 22 *a*, one of the co-types of the red form, is exactly matched by Mr. Shortridge's No. 615, a black "*maurus*," in all the characters mentioned by Dr. Jentink, namely the size of the teeth, the degree of prognathism, the length of the palate, and the form of the chin. And the series shows that there is a good deal of variation in all of these characters. We are therefore compelled to adhere to the usual conclusion (which is confirmed by Mr. Shortridge's note) that the red monkey named *pyrrhus* by Horsfield is an abnormal red form of the usual black animal that has gone by the name of *maurus* or *maura*.

But, so far as names are concerned, the specific term *maura* Schreber, which has hitherto been used for this animal, should give place to *pyrrha*. For the primary basis of Schreber's *maura* was the "Middle-sized Black Monkey" of Edwards, whose plate and description show that it was not this species at all, but a West African Mangabey, possibly *Cercocebus fuliginosus* E. Geoff.

We do not think the evidence for the identification of Geoffroy's

* Notes Leyd. Mus. xiv. p. 119 (1892).

auratus (Ann. Mus. Hist. Nat. xix. p. 93, 1812) with this monkey is sufficient to justify us in using the name. No exact locality was given and the description might apply to any of the forms with pale yellow young, which occasionally keep the youthful pelage throughout life. Horsfield's *pyrrha*, though equally based on an abnormal specimen, is unquestionably this species.

" 'Lütöong' (Soendanese and Javanese).

"Very plentiful. When first born the fur of the young is bright rufous, but soon becomes black as it grows older.

"Abnormal adult rufous individuals occasionally occur in which the black coat has never been assumed."—G. C. S.

3. *PRESBYTIS AYGULA* L.

Semnopithecus vel *Presbytis mitratus* auctorum.

♂. 482 imm., 491. ♀. 476. 481. Tji Wangie, Preanger.

Linnaeus* based his *Simia aygula* on a monkey described by Osbeck† from Java, which can only have been the species to which the name *mitratus* has been usually applied.

" 'Soerēli' (Soendanese).

"Very much more local than the last species. It seems, like *Hylobates*, to be confined to the dense forests in the mountainous parts of West Java. When very young the markings resemble those of *P. comata* from Sumatra."—G. C. S.

4. *MACACA FASCICULARIS* Raff.

♀. 21. Batavia.

♂. 1777. ♀. 1721, 1780. Pangandaran, Dirk de Vries Bay.

♂. 613. ♀. 783. Tjilatjap.

♂. 490. ♀. 470. Tji Wangie, Preanger.

♂. 1219. Tasikmalaja, Preanger.

♂. 1379, 1428. Kalipoetjang, Tji-Tandoei River.

" 'Mūnyet' (Malay). 'Kētēq' (Javanese) (Soendanese).

"Very abundant throughout Java."—G. C. S.

5. *NYCTICEBUS JAVANICUS* E. Geoff.

♂. 1371. Batavia.

" 'Mōoka (Soendanese). Poōkang (Javanese).

"Nocturnal; not plentiful."—G. C. S.

6. *PTEROPUS VAMPIRUS* L.

♂. 22. ♀. 23. Batavia.

♂. 142. ♀. 143. Buitenzorg.

♂. 795, 933. ♀. 790, 794, 796, 797, 843, 934. Tjilatjap.

♂. 1004, 1146, 1159, 1223. Tasikmalaja, Preanger.

* Syst. Nat. (10) i. p. 27, 1758.

† Ostindisk Resa, p. 99, 1757.

♂. 1607, 1608, 1609, 1772, 1773, 1774, 1784, 1789. Pangandaran, Dirk de Vries Bay.

“ ‘Karloug’ (of natives).

“Very plentiful except at high altitudes, especially where they have formed colonies. Flight slow and flapping, occasionally soaring like a bird. They seem to see fairly well by day, and when flying will dip like a crow to avoid a bullet. In the neighbourhood of their colonies there are generally a few flying around all day, while those on the trees are continually altering their positions and quarrelling among themselves, the peculiar screaming that they make being audible for a considerable distance. When disturbed they soon take to flight, circling round the trees like rooks, getting gradually up out of gunshot, although eventually returning to the same place. Many thousands generally collect in one colony, and the trees that they have chosen (which are generally high ones) present a very peculiar appearance, being almost entirely stripped of leaves, while the bats hang in full view in thousands from all the upper branches.”—G. C. S.

7. *ROUSETTUS SHORTRIDGII*.

Thos. & Wrought. Abstr. P. Z. S. 1909, p. 19.

♂. 1905. Kalipoetjang, Tji-Tandoei R., S. Java. 5 March, 1908. B.M. No. 9.1.5.67. *Type*.

Most closely allied to the continental *R. leschenaulti* Desm. †, with which it agrees in having the posterior lower molar elongate instead of subcircular, as it is in *amplexicaudatus* Geoff. Size, however, much greater, the skull especially being markedly larger and heavier, and its crests more strongly developed. Teeth throughout larger and broader, the anterior lower premolar conspicuously larger than in the allied species.

Fur brown above, the hairs with lighter bases; hinder neck nearly naked, paler; a paler patch over the base of the tail. Below, the hairs are everywhere brown with lighter tips.

Dimensions of the type, the starred measurements taken in the flesh:—

Forearm 94 mm.

*Head and body 145; *tail 17; *ear 22; third finger, metacarpal 60, first phalanx 39, second phalanx 51; lower leg and hind foot (c. u.) 66.

Skull: greatest length 42, zygomatic breadth 26.2, interorbital breadth 8.9; supraorbital foramina to tip of nasals 20.5; breadth of brain-case 16.5; palate, breadth outside m² 13; palation to incisive foramina 20.2; front of canine to back of m² 16.1, length of m₂ 2.

Type as above.

This fine Rousset is the largest of the Oriental species, its forearm exceeding those of *R. leschenaulti* and *amplexicaudatus*

† Cf. K. Andersen, Ann. Mag. N. H. (7) xix. pp. 501 et seq., 1907.

by more than 6 mm. Its skull is large and heavy, and its cranial ridges far more developed than in specimens of similar age of the allied forms. In company with it there lives the smallest eastern species, *R. minor*, such a difference in size no doubt tending to reduce competition, and therefore to enable such closely allied forms to live side by side.

R. shortridgei must be exceedingly rare, as getting all the fine series of bats now enumerated, including 34 of the previously almost unknown *R. minor*, Mr. Shortridge only obtained one single specimen of it.

8. ROUSETTUS MINOR Dobs.

♂. 1410, 1411, 1413, 1414, 1439, 1440, 1441, 1445, 1462, 1464, 1508, 1509.

♀. 1409, 1412, 1442, 1443, 1444, 1463, 1465, 1506, 1507, 1510, 1511, 1512.

Four males, six females in spirit.

Kalipoetjang, Tji-Tandoei R., S. Java.

This species has not hitherto been represented in the Museum collection, the only known example of it being the type, preserved in the Calcutta Museum. The present fine series of topotypes is therefore a most valuable accession to the National Collection.

“‘Tjödöt’ (Javanese) (as distinguished from insectivorous bats).

“The smaller fruit-bats are really much more plentiful than *Pteropus vampyrus*, but on account of their smaller size and late appearance in the evenings they are less noticeable. They also seldom roost by day in conspicuous positions, but generally collect in caves, hollow trees, or among dense foliage. When disturbed by day they will dart off sharply in every direction like insectivorous bats. The fruit-bats are a very serious pest in Java, on account of their enormous numbers, and it is chiefly on their account that so much of the fruit is picked green and not allowed to ripen on the trees.”—G. C. S.

9. CYNOPTERUS TITTHACHEILUS Temm.

♂. 8, 12. ♀. 7, 9, 11. Low-lying country, Batavia. And 1 ♀ in al.

♂. 38, 180. ♀. 83. Buitenzorg. 850’.

♂. 531, 532. ♀. 533. Soekaboemi. 2100’.

♂. 684, 687, 689, 690, 914. ♀. 688, 691, 692, 693, 912, 913, 915, 916. Tjilatjap. Sea-level.

♀. 1062. Tasikmalaja, Preanger. 1145’.

The Buitenzorg specimens are absolute topotypes of this fine species, which had not previously been represented in the Museum collection.

Young specimens of *C. titthacheilus* are of a brownish-grey colour, and in other respects have a general likeness to *Rousettus*, for members of which genus they were at first mistaken.

10. *CYNOPTERUS HORSFIELDI* Gray.

♂. 82, 99, 100, 103, 105, 108, 123, 125. ♀. 80, 85, 87, 93, 102, 104, 107, 109, 124. Buitenzorg. 850'.

♂. 671, 778, 784, 818, 849, 861, 911. ♀. 777, 835, 848, 944. Tjilatjap. Sea-level. 1 ♂, 6 ♀ in al.

♀. 1650, 1652. Pangandaran, Dirk de Vries Bay.

♂. 1136. ♀. 1042, 1061, 1137, 1288, 1289. Tasikmalaja, Preanger. 1145.

We use provisionally Gray's name for this Bat, as being unquestionably pertinent to it, but there are several earlier names, based on specimens from Sumatra and elsewhere, which may hereafter prove to be applicable to it. Why Mr. Glover Allen*, in writing of Javan specimens, should use the name *brachysoma* Dobson, when he knew of the 30 years' earlier *horsfieldi*, we do not quite understand.

The males of the Tjilatjap series are particularly brilliantly coloured.

11. *MACROGLOSSUS MINIMUS* Geoff.

♂. 677, 678, 755, 773, 774, 775, 817, 827, 834, 844, 845, 880, 889, 891.

♀. 670, 676, 700, 776, 785, 816, 832, 833, 890, 903. Tjilatjap. Sea-level.

♀. 1006, 1011. Tasikmalaja, Preanger. 1150'.

" 'Tjödöt-mērah' (Javanese). 'Tjödöt-pisang' (Javanese).

" Local, very abundant around Tjilatjap.

" Tongue highly extensile, but probably adapted merely for extracting the pulp from ripe fruit. None of the specimens examined had traces of insects in their stomach. They may be partly honey-eaters. Tail normally 2 to 3 millimetres in length, but frequently entirely rudimentary externally.

" Fully adult specimens of both sexes have a peculiar crescent-shaped gland on the lower part of the throat."—G. C. S.

12. *RHINOLOPHUS BORNEENSIS* Peters.

♀. 875. Tjilatjap.

♂. 1632. ♀. 1655, 1692. Pangandaran, Dirk de Vries Bay, S. Java.

No member of this group of *Rhinolophus* had previously been known from Java.

The posterior process of the nose-leaf is particularly short in these specimens.

" 'Kampret' (Malay). 'Lalli' (Soendanesse). 'Tjödöt' (Javanese) (generally only the smaller fruit-bats). 'Bōoerong-tēkōos' (bird-mouse). 'Lawo' (Javanese).

" Most of the larger insectivorous bats are cave-dwellers, but many of the smaller species hide by day in hollow bamboos,

* Bull. Mus. Harv. lii. p. 25, 1908.

especially in those used in constructing the roofs of houses, and occasionally in the rolled up young leaves of bananas, hollow trees, crevices among rocks, etc."—G. C. S.

13. RHINOLOPHUS AFFINIS Horsf.

♂. 514. ♀. 510, 512, 513, 515, 517, 518. Kottamanah Cave, Soekaboemi. 2100'.

♂. 509. ♀. 516 (in spirit). Do.

♂. 696. Tjilatjap. Sea-level.

♂. 1432, 1433, 1435. ♀. 1434, 1436, 1437, 1461, 1470, 1471, 1472, 1473. Kalipoetjang, Tji-Tandoei R., S. Java.

♂ and 3 ♀ in spirit. Do.

The present fine collection adds considerably to our knowledge of the Javan species of the genus *Rhinolophus*, for while in Dr. K. Andersen's important account of the genus* only six species are recorded from the island (*affinis*, *pusillus*, *acuminatus*, *trifolius*, *luctus*, and *geminus*), no less than three species are now added to the list (*viz. stheno*, *borneensis*, and *canuti*)—thus bringing the total up to nine.

14. RHINOLOPHUS ACUMINATUS Pet.

♂. 24, 95, 98. ♀. 76, 86, 88, 89, 91, and ♀ in al. Buitenzorg. 850'.

♂. 1171, 1172, 1176, 1177, 1178, 1180, 1183. ♀. 1170, 1173, 1174, 1175, 1179, 1181, 1182, 1184, 1185. Tasikmalaja, Preanger. 1150'.

3 ♂, 5 ♀ in spirit. Do.

With the exception of one more rufous individual, these specimens are all dark smoky grey, while in *affinis* the usual colour is more or less buffy. Some few individuals of the latter, however, approximate to the colour of *acuminatus*.

It is noticeable that the two species were not obtained at any one locality, as though they competed with each other too closely to live in the same districts.

15. RHINOLOPHUS STHENO K. Anders.

♂. 1476, 1493. ♀. 1429, 1475. Kalipoetjang, Tji-Tandoei R., S. Java.

Described by Dr. Andersen from the Malay Peninsula†, and afterwards recorded by him from Sumatra‡.

These specimens are all of a more or less buffy or fulvous colour, while the skins of *Rh. borneensis* are uniformly dark grey. Even on the dried skins *Rh. stheno* may be distinguished from *Rh. borneensis* by the much longer posterior lancet of its nose-leaf.

* Ann. Mag. N. H. (7) xvi. p. 656, 1905.

† P. Z. S. 1905, ii. p. 91.

‡ Ann. Mus. Genov. (3) iii. p. 24, 1907.

16. RHINOLOPHUS PUSILLUS Temm.

R. minor Horsf., nec *Vespertilio ferrum-equinum minor* Kerr (1792), which is a *Rhinolophus*.

♀. 504. Kottamanar Cave, Soekaboemi. 2100'.

♀. 1236. Tasikmalaja, Preanger. 1145'.

♀. 1477. Kalipoetjang, Tji-Tandoei R., S. Java.

17. RHINOLOPHUS CANUTI.

Thos. & Wrought. Abstr. P. Z. S. 1909, p. 18.

♂. 1431, 1474. ♀. 1430, 1504. Kalipoetjang, Tji-Tandoei River, S. Java. 2 & 4 March, 1908.

Closely allied to *Rh. creaghi* Thos., described in 1896 from N. Borneo*, but distinguished by the following characters:—The usual connecting-process between the sella and the posterior lancet, obsolete (as a unique character) in *creaghi*, is here represented by a narrow crest on the hinder side of the sella, less than 1 mm. in depth, and joining the posterior process low down; therefore very different from the usual high connecting-process, between which and the obsolete one of *creaghi* it forms an intermediate stage; the upper profile of the crest is evenly rounded above and joins the top of the front face of the sella at a sharp angle, without any intervening notch such as is usually formed by the front surface of the sella projecting a little higher upwards than the anterior point of the connecting-process. The tuft of hair on the front face of the posterior process is very much longer and more abundant, hiding the posterior end of the connecting-process, and forming a most striking and prominent feature of the bat; the hairs forming the tufts are shining golden yellow, and cover the whole middle part of the posterior leaf, some of them also going on the sides of the connecting-process and on the back of the sella; there are also fine tufts of hair on each side at the junction of the horseshoe with the outer bases of the posterior process. The skull is essentially similar to that of *creaghi* in the development and shape of the rostral projection, which is, however, slightly higher, and has its front edge vertically above the anterior part of p^1 , while in *creaghi* that edge is over the back of the same tooth, the canine-bearing part of the jaw in front of the projection appearing therefore to be longer in *creaghi* than in *canuti*.

P^1 in the tooth-row; p_3 minute, external, p_1 and p_4 touching each other internal to it; in one jaw out of eight it is absent.

Forearm 50 mm. Length of skull from occiput to front of canine 22.5.

Head and body 65 mm.; tail 22; ear 24.

Hab. as above.

* Ann. Mag. N. H. (6) xviii. p. 244. In the eighth line of this description, for the word "sella" read "posterior process." The second lower premolar (p_3), said to be "entirely absent," proves, on the skull being cleaned, to be present on one side, though excessively minute.

Type. Adult male. B.M. No. 9.1.5.183. Original number 1431. Collected 2 March, 1908.

We have named this striking species of *Rhinolophus*, which connects the aberrant *R. creaghi* with the more normal species of the genus, in honour of Dr. Knud Andersen, in recognition of the exhaustive work he has done on this complicated and difficult group.

18. *HIPPOSIDEROS DIADEMA* Geoff.

♂. 1126, 1147, 1302, 1303. ♀. 1296, 1301. Tasikmalaja, Preanger. 1150'.

♂. 1383, 1403, 1406, 1407, 1422, 1423, 1494, 1515. ♀. 1405, 1421, 1424. Kalipoetjang, Tji-Tandoei R., S. Java.

♂. 1603. Pangandaran, Dirk de Vries Bay, S. Java.

Representative of *H. nobilis* Horsfield.

19. *HIPPOSIDEROS BICOLOR* Temm.

♀. 499, 500, 505. Kottamanah Cave, Soekaboemi. 2100'.

♀ in al. Tjilatjap.

20. *HIPPOSIDEROS LARVATUS* Horsf.

♂. 1385, 1386, 1391, 1446. ♀. 1384, 1387, 1388, 1389, 1390, 1392, 1447, 1448. Kalipoetjang, Tji-Tandoei R., S. Java.

♂. 1604, 1647, 1653, 1674, 1675, 1679. ♀. 1605, 1648, 1649, 1677, 1678, 1680, and 10 specimens (4 ♂, 6 ♀) in spirit. Pangandaran, Dirk de Vries Bay, S. Java.

The forearms of these specimens run from 55 to 59 mm. in length. Dobson gives 2.45 in. (= 62.5 mm.).

Of the 24 individuals in skin, four (all females) are strongly suffused with yellowish.

21. *CÆLOPS FRITHII* Bly.

♂. 1024, 1025, 1026. Tasikmalaja, Preanger. 1145'.

Topotypes of *C. bernsteini* Peters.

These examples of this exceedingly rare Bat are particularly welcome, as representing Peters's *C. bernsteini*, which is not improbably distinguishable from Blyth's *C. frithii*. But pending further investigations we use the name adopted by Dobson.

The recently described *C. robinsoni* Bonh., from Selangore, is much smaller than either.

22. *MEGADERMA SPASMA TRIFOLIUM* Geoff.

♂. 74. Buitenzorg. 850'.

♂. 853, 856, 863, 866, 870, 874, 878, 894. ♀. 695, 739, 854, 855, 857, 858, 865, 867, 868, 869, 871, 872, 873, 879, 892, 893. Tjilatjap.

♂. 1155. Tasikmalaja, Preanger. 1150'.

23. *PETALIA JAVANICA* Geoff.

♀. 81, 90, 97. Buitenzorg. 850'.

♂. 643, 649, 650, 651, 652, 655, 656, 657, 658, 659, 662.
♀. 642, 644, 645, 647, 653, 654, 661, 663. Cave on sea-coast, Tjilatjap. And 1 ♂ and 11 ♀ in al.

♂. 1029, 1030. ♀. 1027, 1028. Tasikmalaja, Preanger.

Although the general colour of these specimens varies considerably, from grey to fulvous, yet the latter colour is no more dominant or intense in the males than in the females, as might perhaps have been expected.

Dobson's record of "Timor" for an example of this species is in all probability erroneous, as the specimen was purchased from a dealer, and the entry of its locality in the register is somewhat ambiguous.

24. *TYLONYCTERIS PACHYPUS* Temm.

♂. 41, 42. ♀. 94, 132. Buitenzorg. 20 ♂ and 42 ♀ in al.

♂. 520, 527. ♀. 521, 526, 528. Soekaboemi.

♂. 993, 995, 999, 1093. ♀. 978, 980, 982, 996, 997, 998, 1850, 1078, 1140. Tasikmalaja.

25. *PIPISTRELLUS TRALATITIUS* Horsf.

♀. 5, 224. Batavia.

♂. 126, 185. ♀. 61, 181, 182, 183, 184. Buitenzorg.

♀. 530 and 18 specimens in al. Soekaboemi.

♂. 598, 600, 602, 605. ♀. 597, 599, 601, 606, 608, 609, 610, 611, 626, 627, 697, 698. 10 ♀ in al. Tjilatjap.

♂. 1000, 1001, 1229. ♀. 1035, 1055, 1056, 1200. Tasikmalaja.

This is the Bat for which Dobson uses the name *abramus* Temm., although Horsfield's name is earlier and one of the specimens the former enumerates (*w'*) he states to be labelled "Lowo-manir," the native Javanese name recorded in Horsfield's original description. Specimen A of Horsfield's 'Catalogue of the Indian Museum' (p. 39), now B.M. No. 79.11.21.124, may be considered as the type of *tralatitius*.

As elsewhere in the East, this Bat seems to be excessively common in Java.

26. *PIPISTRELLUS IMBRICATUS* Horsf.

♀. 756, 757, 758, 760. Tjilatjap.

27. *SCOTOPHILUS TEMMINCKII* Horsf.

♂. 35, 67, 69, 111, 118, 120, 121, 127, 128, 130, 137, 138.

♀. 68, 113, 114, 115, 116, 119, 129, 159. Buitenzorg. 850'.

♂. 225. Batavia.

♂. 524. ♀. 519, 525. Soekaboemi.

♂. 611, 806, 813, 829, 830, 831, 838, 839, 840. ♀. 805, 807, 808, 809, 827, 828, 836, 927. Tjilatjap.

♂. 972, 1091, 1161, 1207. ♀. 1092, 1204, 1206. Tasikmalaja, Preanger. 1150'.

We use the name *temminckii* for these bats, as being undoubtedly pertinent to them, pending such time as the type of *kuhli* can be definitely assigned to one or other form of *Scotophilus*.

28. MURINA BALSTONI THOS.

Ann. Mag. N. H. (8) ii. p. 370. 1908.

♀. 1160. Tasikmalaja, Preanger, 1145. B.M. No. 9.1.5.354. Type.

This, the first new species distinguished of the fine Javan collection made by Mr. Shortridge, was named by Thomas after Mr. W. E. Balston, to whom the National Museum owes this magnificent addition to its collections.

The distinctive characters of *M. balstoni* are enumerated in the paper above referred to.

29. HARPIOCEPHALUS HARPIA Temm.

♂. 901, 902. ♀. 899, 900. Tjilatjap. 10 Dec., 1907.

♀. 1287. Tasikmalaja, Preanger. 1145'. 28 Jan., 1908.

Compared with these specimens the Himalayan form is obviously different by its darker and more chocolate colour. It should bear the name of *H. lasyurus* Hodgs.*, of which the Museum specimen No. 79.11.21.119 is the type. Horsfield's *Lasiurus pearsoni*, also from Darjiling, would be a synonym of it.

30. MYOTIS sp. (near MURICOLA).

♂. 26, 27, 96, 134, 140. ♀. 29, 135. 5 ♂ and 19 ♀ in al. Buitenzorg.

♂. 803, 885, 887. ♀. 802, 804, 886, 925. Tjilatjap.

♂. 977, 1162, 1191, 1193. ♀. 1139. Tasikmalaja, Preanger.

31. MYOTIS (LEUCONOE) HASSELTII Temm.

♂. 1017, 1054, 1069, 1070, 1071, 1072, 1073, 1090, 1100, 1101, 1102, 1103, 1104, 1106, 1111, 1112, 1113, 1114, 1192, 1194. ♀. 1074, 1105, 1107, 1108, 1109, 1110, 1132. Tasikmalaja, Preanger.

32. MYOTIS (LEUCONOE) ADVERSUS Horsf.

♀. 1621, 1622, 1623, 1637, 1638, 1639, 1640, 1643, 1651, 1656, 1657, 1658. ♀. 1614, 1615, 1616, 1617, 1618, 1619, 1624, 1633, 1641, 1644, 1645. Pangandaran, Dirk de Vries Bay.

33. KERIVOULA PICTA Pall.

♀. 819, 820. Tjilatjap. Sea-level. 27 Nov., 1907.

“‘Lawo-Kambang’ (Javanese).”—G. C. S.

* J. A. S. B. xvi. p. 896, 1847.

34. *KERIVOULA HARDWICKEI* Horsf.

♂. 14, 16. Batavia (in spirit).

♂. 1065, 1135. ♀. 1063, 1064, 1066, 1067, 1068, 1125, 1148. Tasikmalaja, Preanger. 1145'.

Dobson's Catalogue measurement of 1·4 in. for the forearm of *K. hardwickei* is more than any of these specimens show, as they run from 31–33 mm., therefore only rarely reaching 1·3 in., which was the size of his *K. fusca*, later synonymized by him with *K. hardwickei*.

35. *MINIOPTERUS BLEPOTIS* Temm.

♂. 1396, 1398, 1399, 1500, 1518, 1519, 1533, 1534, 1536, 1537. ♀. 1393, 1394, 1395, 1397, 1400, 1401, 1402, 1516, 1517, 1535. 9 ♀ and 1 ♂ in al. Kalipoetjang, Tji-Tandoei R.

♂. 1152. ♀. 1151. Soekaboemi, Preanger.

Topotypes. Temminck gives length of forearm as 45·5 to 47·5; the present series vary from 44·5 to 46, but those of the two specimens from Soekaboemi measure 50 mm.

36. *MINIOPTERUS MEDIUS*, sp. n.

♂. 1498. ♀. 1497, 1499, 1501, 1502. And 1 ♂, 2 ♀ in al. Kalipoetjang, Tji-Tandoei R.

A *Miniopterus* intermediate in size between *M. blepotis* and *M. tibialis*.

Not differing materially in outward facies from *M. blepotis*, except in size. Black and red phases of colouring of the coat present as is usual in the genus.

Dimensions of the type, the starred measurements taken in the flesh :—

Forearm 42 mm.

Head and body *55; tail *47; hind foot *9; ear *12; terminal phalanx of middle finger 35.

Skull: greatest length 15; basi-sinual length 11·5; brain-case breadth 7·5; greatest width across canines 6·5; front of p⁴ to back of m³ 4·4.

Hab. Kalipoetjang, Tji-Tandoei R., Java.

Type. Adult female. B.M. No. 9.1.5.464. Original number 1499. Collected 4 March, 1908.

37. *MINIOPTERUS TIBIALIS* Tomes.

♂. 1451, 1453, 1454, 1456, 1457, 1458, 1483, 1486, 1492. ♀. 1449, 1450, 1452, 1455, 1459, 1460, 1481, 1482, 1484, 1485, 1487, 1488, 1489, 1490, 1491. And 5 ♀ in al.

38. *EMBALLONURA MONTICOLA* Temm.

♀. 1514. Kalipoetjang, Tji-Tandoei R., S. Java.

♂. 1602, 1628, 1629, 1634, 1636, 1664, 1672. ♀. 1600, 1601, 1612, 1630, 1635, 1659, 1660, 1661, 1662, 1663, 1665, 1666, 1668,

1669, 1670, 1671, 1673. Pangandaran, Dirk de Vries Bay, S. Java.

Most of these specimens are rather larger than is indicated in Temminck's description, which gives a forearm length of "1 duim 7 lijnen" (=43 mm)*. Their forearms range from 43.5 to 48 mm.

39. *TAPHOZOUS LONGIMANUS* Hardw.

♂. 6. Batavia. Sea-level.

♂. 672. Tjilatjap. Sea-level.

These specimens are paler than usual, but this may be due to bleaching, or to a variation of the same nature as that found in Blyth's "*fulvidus*."

40. *TAPHOZOUS THEOBALDI* Dobs.

♂. 1415, 1417, 1418, 1419, 1420, 1469, 1479, 1480, 1496.

♀. 1416, 1426, 1478, 1495. Kalipoetjang, Tji-Tandoei R., S. Java.

3 ♂, 5 ♀ in spirit. Do.

This rare Bat was hitherto only known from the typical specimens in the Calcutta Museum, of which one has been given to the British Museum, and has enabled us to compare Mr. Shortridge's specimens with it. We can find no essential difference between the Javan and Tenasserim forms, although when fresh skins of the latter are available some difference in colour may prove to exist.

As represented by the Javan specimens, *T. theobaldi* has a blackish throat, recalling the black beard of *T. melanopogon*, but the black is not so deep nor so sharply defined laterally as in that animal.

41. *TAPHOZOUS SACCOLAIMUS* Temm.

♀. 1363. Tasikmalaja, Preanger.

42. *CHEREPHON PLICATUS* Buch.-Ham.

♂. 58, 59, 62, 112. ♀. 57. Buitenzorg. 850'.

♂. 535, 537. ♀. 508, 534, 536. Soekaboemi.

♂. 946, 947, 948, 949, 950, 952, 954, 955, 956, 957, 971.

♀. 951, 953. Tjilatjap.

♀. 1290. Tasikmalaja, Preanger. 1150'.

And 1 ♂, 5 ♀ in al. Batavia.

Represent Horsfield's *Nyctinomus tenuis* and *dilatatus*.

The Tjilatjap specimens Nos. 946-957 are all quite young.

"Very active on the ground, and even when young and unable to fly is able to run about like a mouse, especially in rough situations."—G. C. S.

* Not 40 as stated by Miller, who has taken Temminck's measurement as though the inches were English ones instead of French. As a consequence, there is no difference at all in size between *E. monticola* and *E. peninsularis* Miller.

43. *GALEOPTERUS VARIEGATUS* Geoff.

♂. 213. Batavia.

♂. 1720, 1727, 1729, 1731 imm.; 1775, 1776. ♀. 1610, 1716, 1717, 1724, 1730, 1778, 1779 imm. Pangandaran, Dirk de Vries Bay.

“ ‘Tāndo’ (Soendaneese). ‘Wālang-kōpo’ (Javanese). ”

“Nocturnal. This animal possesses a very strong and peculiar smell, which originates from an open gland at the root of the tail. This gland is in the form of a shallow pouch—more developed in the males—and, during life, a vivid orange in colour. The fur of the normal-coloured variety of the species has a distinct suffusion of green during life that at once disappears when the skin is dry. This peculiarity is also noticeable in *Tupaia*.”—G. C. S.

44. *TUPAIA JAVANICA* Horsf.

♂. 148, 174, 175, 189, 247, 248. ♀. 51, 52, 156, 246. Buitenzorg.

♂. 750. ♀. 679. Tjilatjap.

♂. 485. ♀. 473. Tji Wangie, Preanger.

♂. 1009, 1010, 1023, 1046, 1047, 1052, 1094, 1130, 1167, 1210, 1211, 1213, 1239, 1240, 1248, 1254, 1292. ♀. 1018, 1019, 1020, 1021, 1037, 1053, 1075, 1157, 1158, 1166, 1168, 1169, 1222, 1227, 1241, 1247, 1253. Tasikmalaja, Preanger.

“ ‘Kēkkas’ (Soendaneese). ‘Emess.’ ”

“Diurnal—bearing an extraordinary resemblance to the smaller squirrels both in habits and movements; frugivorous and insectivorous.”—G. C. S.

45. *CROCIDURA* sp.

♀. 45. Buitenzorg.

46. *PACHYURA MURINA*.

♀. 13. Batavia.

♂. 47, 63, 75, 79, 147, 163, 179, 188. ♀. 28, 46, 56, 64, 144, 187, 190, 203. Buitenzorg.

♂. 881. Tjilatjap.

“ ‘Tēkoos-tjerōot’ or ‘Chulerōot’ (Jav., Soend., Mal.). ”

“Probably originally introduced.

“Both species of Shrew seem to be most plentiful in thickly populated localities, especially around seaport towns.”—G. C. S.

47. *FELIS PARDUS* L.

1307 (black variety). Tasikmalaja, Preanger.

1156, ♂ 1294. Tasikmalaja, Preanger.

1260. Pangandaran, Dirk de Vries Bay.

“ ‘Mātjan-tootool’ (Soend., Jav.). ‘Mātjan-kāmbang’ (black var.). ”

“Comparatively plentiful throughout Java, particularly in mountainous and thinly populated districts.”—G. C. S.

48. *FELIS JAVANENSIS* Desm.

239, 1328, 1329 imm., 1330. Batavia.

♂. 53 imm., 110 imm., 171, 855 imm. Buitenzorg.

♂. 1685 imm., 1686 imm. Pangandaran, Dirk de Vries Bay.

♂. 791. Tjilatjap.

♂. 1165, 1233 imm., 1245 imm., 1364 imm. ♀. 1257 imm., 1367 imm., 1368 imm. Tasikmalaja, Preanger.

“‘Méong-chôngkok’ (Soendanese). ‘Blâtjan’ (Javanese).

“Very plentiful. Appears to occasionally cross with the domestic cat.

“The domestic cats in Java almost invariably have distorted tails, which are either stunted or have the appearance of being disjointed, often in several places, the end being sometimes almost at right angles with the base; very few, except recently imported individuals, possess perfect tails.”—G. C. S.

49. *VIVERRICULA RASSE* Horsf.

18, 230, 231, 233 imm., 234, 236. ♀. 37, 227. Batavia.

164, 167 imm. ♀. 39, 169. Buitenzorg.

♂. 741 imm., 742 imm., 847 imm., 970 imm. Tjilatjap.

♂. 1127, 1164, 1242, 1284 imm., 1285 imm., 1286 imm., 1293, 1298. ♀. 1058, 1209, 1224, 1244, 1297 imm., 1299 imm. Tasikmalaja, Preanger.

“‘Rässie’ (Malay). ‘Deddëss’ (Soendanese).

“Very plentiful. It is curious that so many of the native mammals in Java, especially the small carnivores, abound in the densely populated districts. *Viverricula*, *Paradoxurus*, *Mungos*, *Felis javanensis*, etc., seem to have entirely adapted themselves to an artificial, almost semi-domestic life, existing in abnormal numbers around towns and native villages, where they probably live almost exclusively on the swarms of house-rats and poultry that are always in such numbers in the vicinity of houses. *Viverricula* is often kept alive, or hunted for by the natives, who collect its civet either as a perfume or for flavouring their tobacco.

“It is astonishing how many even of the carnivorous mammals of Java are partly frugivorous. In fact, there are few, if any, mammals of any kind there that will not feed on bananas.”—G. C. S.

50. *PARADOXURUS JAVANICUS* Horsf.

♂. 43, 162, 194. ♀. 44, 55, 70, 131, 202. Buitenzorg.

1331, 1332, 1333. Batavia.

♂. 1525. Kalipoetzang, Tji-Tandoei River.

♂. 1783 (imm.). ♀. 1706. Pangandaran, Dirk de Vries Bay.

♀. 935. Tjilatjap.

♂. 1133 imm., 1134 imm., 1163, 1258 imm. ♀. 1098 imm., 1150 imm., 1153 imm., 1154 imm., 1214 imm., 1251 imm., 1259 imm., 1260 imm., 1369 imm., 1370 imm. Tasikmalaja, Preanger.

“‘*Lōoark*’ (Jav.). ‘*Tjareuh*’ (Soend.).

“Very plentiful, largely frugivorous. Known in Java as the Coffee-Cat, on account of its habit, when in the neighbourhood of coffee-plantations, of feeding largely on the berries. The undigested berries, which are afterwards dropped, are found in heaps and carefully collected by the natives, and as the animals pick out the ripest and best fruit, *Lōoark*-coffee is considered the finest.

“Around houses it is often considered a useful factor in keeping down the enormous numbers of house-rats that overrun so many parts of Java; it is, however, frequently very destructive to poultry. Often hides by day in the roofs of houses or out-buildings. Although its general scent resembles that of *Viverricula*, its gland-pouch is more or less rudimentary and does not produce civet.”—G. C. S.

51. *CUON JAVANICUS* Desm.

♂. 150 imm. Buitenzorg Museum.

“‘*Adjac.*’ ‘*Gārong*’ (Soendanes). ‘*Āndjing-oōtan*’ (Malay).

“Confined to the more inaccessible and mountainous parts of Java. Said to be fairly numerous among the mountains of East Java.

“I think that the native Campong-dog has most probably at least partly originated from this species, and that *C. javanicus* will, like the Dingo of Australia, occasionally cross with domestic varieties.”—G. C. S.

52. *ARCTICTIS BINTURONG* Raff.

1308. Near Tasikmalaja.

“‘*Matjan-thongkok.*’ ‘*Sāro-gārlong.*’

“Apparently rare in Java. Said to frequent the banks of rivers.”—G. C. S.

53. *MUNGOS JAVANICUS* E. Geoff.

232, 1320, 1321, 1322, 1323, 1324, 1325, 1326. ♂. 228. Batavia.

♂. 71 imm., 191 imm., 192 imm. Buitenzorg.

♂. 896. ♀. 846 imm. Tjilatjap.

♂. 1304. ♀. 1235, 1250, 1283, 1291. Tasikmalaja, Preanger.

“‘*Garāngan*’ (Jav.). ‘*Gānggarāngan*’ (Soendanes).

“Fossorial; principally nocturnal; very plentiful.”—G. C. S.

54. *HELICITIS ORIENTALIS* Horsf.

153, 154. Buitenzorg Museum.

♂. 205. Buitenzorg.

♂. 1234 imm. ♀. 1225, 1243. Tasikmalaja, Preanger.

“‘*Beoöl*’ (Soendanes).

“Nocturnal and fossorial. This species has no offensive smell. Probably mimics *Mydaus* in its coloration, and like that animal it frequents mountainous localities.”—G. C. S.

55. MYDAUS JAVANENSIS Desm.

483. ♀. 478. Tji Wangie, Preanger.

♂. 149 imm., 152, 168, 178, 197 ♀. 145, 195, 200.
Buitenzorg.

The specific name *meliceps*, given by F. Cuvier, Mamm. pl. 129, April 1821, is antedated by *javanensis* Desmarest, Mamm. p. 187, 1820; and as both were based on a specimen collected by Leschenault de Latour, there can be no question as to their identity.

“‘Segoong’ (Soendanese).

“Nocturnal and fossorial. Rather sluggish in its movements. Its offensive smell, especially when disturbed or irritated, can hardly be exaggerated. Plentiful in the mountainous districts of West Java.”—G. C. S.

56. LUTRA CINEREA Ill.

♂. 1684. ♀. 1682. Pangandaran, Dirk de Vries Bay.

♂. 34 imm., 77 imm., 170 imm. ♀. 33 imm., 78 imm.
172 imm. Buitenzorg.

1314 imm. Batavia Museum.

♂. 25 imm. Batavia.

“‘Sāro’ (Javanese; Soendanese). ‘Linsang’ (Jav.).

“Nocturnal; plentiful in swampy places and along the sea-shore.”—G. C. S.

57. PETAURISTA NITIDA Desm.

157, 158. Buitenzorg Museum.

477. Tji Wangie, Preanger.

“‘Belook’ (Soend.). ‘Kooōboong.’

“Nocturnal; apparently local. Said to be fairly plentiful in some districts.”—G. C. S.

58. SCIUROPTERUS (HYLOPETES) SAGITTA L

S. lepidus Horsf., auct.

♂. 897. ♀. 898. Maos, near Tjilatjap.

♂. 1626, 1627, 1790. ♀. 1625, 1791. Pangandaran, Dirk de Vries Bay.

♂. 1427. Kalipoetjang, Tji-Tandoei R.

We think we may venture now definitely to determine Linnæus's *Sciurus sagitta*, which has been so long a puzzle to workers on this group, its name having been assigned to quite a number of different forms. Its locality is stated to be Java, and in that island there are only two Flying Squirrels of which the phrase “*statura Sciuri vulgaris*” could be used, namely, *S. lepidus* Horsf. and *S. genibarbis* Horsf., and from the latter of these it is separable by “*seta una in mala*,” sufficiently applicable to the present animal. One statement only is inconsistent with this conclusion, namely “*cutis extensa a capitis ad carpum*,” as though there were an antebrachial membrane as in the genus *Petaurista*.

But as the specimen was clearly adult ("*scrotum magnum*") it could not have been a young *Petaurista nitida*, and we can only suppose that there was some error of observation in the matter of the antebrachial membrane.

S. sagitta is a *Hylopetes* nearly allied to *S. aurantiacus*, *spadiceus*, and *everetti*.

"'Mon-mon' (Soendanesse). 'Chōōbok' (Javanese). 'Ēntjang-ēntjang.'

"*Sciuropterus* and *Petaurista* are nocturnal, while all the other Javanese Squirrels seem to be diurnal.

"*S. sagitta* chiefly occurs among cocoanut-plantations, and either makes its nest in an empty cocoanut or among leaves at the top of a palm."—G. C. S.

59. RATUFA BICOLOR Sparrm.

155 (juv.). Buitenzorg Museum.

♂. 1381, 1382, 1425, 1520, 1522, 1526, 1529, 1530. ♀. 1378, 1513, 1527, 1528, 1531. Kalipoetjang, Tji-Tandoei River.

♂. 1698, 1710, 1711, 1723. ♀. 1683, 1722, 1725, 1726. Pangandaran, Dirk de Vries Bay.

♂. 1295. ♀. 1057. Tasikmalaja, Preanger.

"'Bādjing-djalarang' (Soend.) (Jav.).

"In uncultivated forest-districts; local, often very plentiful where it occurs."—G. C. S.

60. SCIURUS NOTATUS Bodd.

♂. 1, 3 (imm.), 15 (imm.). ♀. 2, 19. Batavia.

♂. 31, 49, 54, 245. Buitenzorg.

♂. 1468. ♀. 1532. Kalipoetjang, Tji-Tandoei River.

♀. 1613. Pangandaran, Dirk de Vries Bay.

♂. 603, 612, 624, 625, 629, 630, 631, 680, 801 (imm.). ♀. 607, 619, 623, 632, 633, 681. Tjilatjap.

Examination of this series proves that Bonhote's *S. andrewsi* * from Tjigombong cannot be separated from *S. notatus*.

"'Bādjing-klāpa' of natives.

"Very abundant among cocoanut-plantations in low-lying country. In the mountainous and uncultivated localities its place is taken by *Sciurus nigrovittatus*. Although feeding on most fruits, it seems to be especially partial to the cocoanut-palm, to which it is very destructive. When feeding on a cocoanut it bores a circular hole in one side of the shell. Natives frequently fasten a piece of sheet tin around the trunks of the palms about halfway up, as the tin offering no foothold prevents the squirrels from ascending to the fruit."—G. C. S.

61. SCIURUS NIGRO-VITTATUS Horsf.

♂. 36 (imm.), 48, 186 (imm.), 244, 469. Buitenzorg.

♀. 1380, 1503. Kalipoetjang, Tji-Tandoei R.

* Ann. Mag. N. H. (7) vii. p. 456, 1901.

♂. 618, 747, 751, 752, 753, 754, 780, 781. ♀. 635, 748, 782, 789. Tjilatjap.

♀. 471, 472, 488, 489 (imm.). Tji Wangie, Preanger.

♂. 743, 745. ♀. 744, 746. Noesa Kambangan Island.

“ ‘Bādjing-ootan.’ ”

“ Very plentiful in all the forest-districts. Unlike *S. notatus* it avoids cultivation. Partly insectivorous.”—G. C. S.

62. *LARISCUS** *INSIGNIS* JAVANUS.

Laria insignis javana, Thos. & Wr. Abstr. P. Z. S. 1909, p. 19.

♂. 65. Buitenzorg.

♂. 484. Tji Wangie, Preanger.

A *Lariscus* of the same general pattern as *L. insignis*, but rather larger and stouter, and darker in coloration than any of the races of that species.

Size rather larger than *L. insignis* of Sumatra. Fur about 15 mm. in length on the back, 30–35 mm. on the tail. General colour-pattern as in the various races of *L. insignis*, but differing from all of them in the darkness of the interspaces between the dorsal stripes. Individual hairs of tail black, with a buff band (5 mm. broad) at 5 mm. from the base, and with a white tip (5 mm.); the outer black band (15 mm.) is much broader than in other forms of *L. insignis*, in which it measures at most 10 mm.

Skull with a long pointed muzzle, palatilar length 24 mm. as compared with 19–22 mm. in *L. insignis* and its Malayan forms. Teeth larger and stouter. Profile of skull much flatter.

Dimensions of the type:—

Head and body 220 mm.; tail (broken); hind foot 47; ear 18.

Skull: greatest length 53; basilar length 41; zygomatic breadth 28; interorbital breadth 14; palatilar length 24; diastema 14; upper tooth-series, exclusive of p^3 9.3.

Hab. Java (type from Buitenzorg). Alt. 855'.

Type. Adult male. B.M. No. 9.1.5.718. Original number 65. Collected 2 August, 1907.

The second specimen, an old male, from Tji Wangie, Preanger (alt. 4000'), agrees with the type in all essential characters. The dark dorsal area, the broad black longitudinal stripe of the tail, the long narrow muzzle, and large stout teeth serve easily to distinguish this subspecies from typical *L. insignis* and its Malayan races, *peninsulæ* and *jalorensis*.

“ ‘Bo-oot’ (Soendanese).

“ Mountainous districts.”—G. C. S.

63. *NANNOSCIURUS MELANOTIS* Müll. & Schl.

♂. 208. ♀. 209. Buitenzorg.

* Nom. nov. *Laria* Gray, 1867, nec Scopoli, Entomol. Carniol. p. 21, 1763. Type *L. insignis*.

64. *CHIROPDOMYS ANNA*.

Thos. & Wrought. Abstr. P. Z. S. 1909, p. 19.

♂. 501, 503. ♀. 502. Kattamanah, Soekaboemi.

♂. 674, 860, 932. ♀. 799, 822. Tjilatjap.

♂. 1212, 1237, 1256, 1361. ♀. 1128, 1129, 1246, 1306. Tasikmalaja, Preanger.

151, 193 Java.

A *Chiropodomys* outwardly resembling *C. gliroides*, but with a smaller skull and teeth.

Size intermediate between the Bornean *C. major* and *C. pusillus*. Fur rather short (6-7 mm. on the back), but close and fairly soft.

General colour above between "isabella" and "fawn," the individual hairs being "slate-colour" with "russet" tips; under surface pure white, the hairs white to their bases. Hands and feet whitish, the latter with dark central line above. Tail nearly half as long again as the head and body.

Dimensions of the type (the figures in brackets are those of a specimen of *gliroides* of similar age from Tenasserim):—

Head and body 87 mm.; tail 112; hind foot 18; ear 16.

Skull: greatest length 24 [26]; basilar length 8·5 [20·5]; zygomatic breadth 14 [15]; brain-case breadth 11·6 [13]; diastema 6·3 [7·3]; palatal foramina 3 [4·3]; upper molar series 3·8 [4].

Hab. Tjilatjap, Java (sea-level).

Type. Adult female. B.M. no. 9.1.5.757. Original number 822. Collected 27 Nov., 1907.

Eighteen specimens examined, of both sexes and all ages.

In many respects this species is intermediate between the mainland *C. gliroides* Bly. (syn. *peguensis* Bly., *penicillatus* Pet.) and the Sumatran *C. niadis* Miller.

"Tēkoos-klapa, Tēkoos-sārwa, Nying-Nying.

"Arboreal; similar in habits to the dormouse, making small grass nests among bamboos or the heads of palm-trees.

"Very plentiful in many localities; seems to feed to a large extent among rice-fields."—G. C. S.

65. *MUS RATTUS* (*neglectus* group).

♂. 17. ♀. 4. Batavia.

♂. 40, 50, 84, 199. ♀. 32, 122, 133. Buitenzorg.

♂. 628, 638, 641, 682, 738, 936. ♀. 639, 640, 664, 665, 821, 883, 884, 943. Tjilatjap.

♂. 1115, 1201, 1202, 1208, 1252, 1262, 1264, 1266, 1267, 1268, 1269, 1270, 1271, 1272, 1274, 1275, 1276, 1277, 1278, 1372, 1374, 1375. ♀. 1022, 1040, 1041, 1220, 1249, 1261, 1263, 1265, 1273. Tasikmalaja, Preanger.

♂. 1538. Kalipoetjang, Tji-Tandoei River.

"'Tēkoos' of natives.

"Swarming throughout Java, particularly in thickly populated localities."—G. C. S.

66. *MUS* sp. (*concolor* group).

♂. 495, 497. ♀. 494, 496, 498.

67. *MUS MUSCULUS* Linn.

♀. 30, 73, 141. Buitenzorg.

♂. 646, 864. Tjilatjap.

♂. 583. ♀. 584. Soekaboemi.

♂. 1279, 1280, 1281, 1282. Tasikmalaja, Preanger.

68. *BANDICOTA SETIFERA* Horsf.

♂. 1051. Tasikmalaja, Preanger.

♂. 1611. Pangandaran, Dirk de Vries Bay.

The first specimens of the Javan Bandicoot received since the arrival of the original co-type, a faded and deteriorated skin transferred from the Indian Museum in 1879.

Hermann's *Mus javanus* might have been supposed to have been this species were it not for his distinct statement that its feet were white, while in *B. setifera* they are dark brown. There is, I think, little doubt that *M. javanus* was based on an example of *Mus norvegicus*.

“‘Tēkoos-djāntang.’ ‘Tēkoos-ia.’ ‘Tēkoos-besār.’

“Said to prefer swampy localities and to live in holes in the ground, often among rice-fields.”—G. C. S.

69. *HYSTRIX JAVANICA* F. Cuv.

237, 1310, 1311, 1312, 1313. Batavia.

♀. 176. Buitenzorg.

♀. 669. Tjilatjap.

♀. 1631. Pangandaran, Dirk de Vries Bay.

“‘Landark’ of natives.

“Nocturnal and fossorial; plentiful in many localities, said to do considerable damage among rubber-plantations.”—G. C. S.

70. *LEPUS NIGRICOLLIS* F. Cuv.

240, 241, 242, 1315, 1316, 1317, 1318. ♀. 243. Batavia.

♂. 146, 207. ♀. 177 imm., 204 imm., 206 imm. Buitenzorg.

“‘Klintji’ (Malay).

“Very local; apparently confined to the north-west of Java. Plentiful among sugar-cane plantations around Batavia and Buitenzorg. Probably originally introduced; said to be plentiful in Sumatra.”—G. C. S.

71. *SUS VERRUCOSUS* Müll. & Schleg.

♂. 662, 793, 882. ♀. 666, 667, 669. Tjilatjap.

♂. 1687, 1694 (imm.), 1708, 1785, 1786. ♀. 1688, 1693 (imm.), 1782 (imm.). Pangandaran, Dirk de Vries Bay.

♂. 1466. ♀. 1467. Kalipoetjang, Tji-Tandoei River.

♂. 1149, 1305, 1366. ♀. 1300. Tasikmalaja, Preanger.

“ ‘Bābbi’ (Malay). ‘Tjelleng’ (Javanese). ‘Bāgong’ (Soendaneese). ‘Bāgong-gādoong’ (Soendaneese). ‘Bāgong-wraha.’

“Taking the place of *Sus vittatus* in the inland mountainous districts of Java, but also occasionally occurring with it near the coast.”—G. C. S.

72. *TRAGULUS FOCALINUS* Miller.

1315. Batavia.

♀. 1238. Tasikmalaja, Preanger.

♀. 621, 683. Tjilatjap.

♂. 1606, 1695, 1699, 1702, 1703, 1718, 1719, 1728, 1735.

♀. 1646, 1667, 1676, 1696, 1697, 1700, 1701, 1704, 1705, 1713, 1714. Pangandaran, Dirk de Vries Bay.

“ ‘Kantjil’ (Malay). ‘Pootjang’ (Soendaneese).

“Plentiful in dense forests, particularly in thinly populated districts.

“I could get no information of more than one species of *Tragulus* on the mainland of Java.”—G. C. S.

73. *MUNTIACUS MUNTJAK* Zimm.

♂. 1771. ♀. 1732. Pangandaran, Dirk de Vries Bay.

“ ‘Kidang’ (Javanese). ‘Muntjac’ (Malay, Soendaneese).

“The uncultivated parts of Java, particularly in hilly situations.”—G. C. S.

74. *MANIS JAVANICA* Desm.

♂. 210, 211. Buitenzorg.

♂. 1005. Tasikmalaja, Preanger.

♂. 1306. Batavia.

♀. 1691. Pangandaran, Dirk de Vries Bay.

“ ‘Poising’ (Soendaneese). ‘Tringilling’ (Javanese)

“Fairly plentiful, chiefly in forest country.”—G. C. S.

April 6, 1909.

FREDERICK GILLET, Esq., Vice-President, in the Chair.

The Secretary exhibited, on behalf of Mr. George Jennison, some fertilized eggs from a pair of Seba Pythons in the Belle Vue Zoological Gardens, Manchester, and read the following account of them:—

“The Belle Vue snake-cage is 75 feet long by 10 by 12, forming an annexe to a greenhouse and composed (except the back) entirely of glass. A minimum temperature of 80° is aimed at, and an inner case, in which sat the Seba Python mentioned below, is

provided for retreat from extreme cold. Numerous hanging baskets of growing plants and a wired-off portion which is one mass of tropical vegetation beautify the cage, and make an atmosphere and surroundings congenial to the serpents. These things have had, I believe, great influence in the production of eggs. Only one batch was laid during 10 years in our old snake-cages, whereas, beginning April 1904, there have been six lots of eggs in the new cage, which was first occupied in the summer of 1903.

"Hitherto, with perhaps one exception, the eggs have not been fertilized, but only once has the snake failed to incubate them for a considerable period. And on one occasion a *Python Molurus* permitted herself and eggs to be moved from one situation to another without decreasing her ardour.

"The sitting of a Seba Python, which commenced Dec. 21st and terminated at the 4th of February this year, would probably have been successful had she not been lying on an air-grating, where the temperature would approximate to 120°. The eggs, which were perfectly white, through the whole period were pitted and flattened out of spherical shape until they closely resembled a plaque of white excreta. The reptile sat upon them very assiduously, but left the nest for about 10 minutes morning and evening to drink, and for about half an hour every fortnight when feeding, which she did regularly on *Jasul* rabbits during the whole period.

"During the period of incubation the Python grew more vicious, turning upon the keeper several times and occasionally striking at visitors.

"Nevertheless, she in no way resented the presence of the dozen or more snakes which crowded into the same case in the cold January days, but which usually kept as far from her as possible (about 5 feet), the male Python alone lying at her side.

"This pair of Seba Pythons was purchased from Mr. Lyster Jameson last summer, and had been, I believe, on deposit at Regent's Park for some time previously.

"Slough of female 15 feet long."

Dr. R. T. Leiper, F.Z.S., exhibited a greatly distorted Elephant's tusk from the Congo, and a malformed canine tooth of a Hippopotamus from Uganda, and stated that the conditions most probably had originated from mechanical injury.

Mr. E. T. Newton, F.R.S., F.Z.S., exhibited a metatarsal bone of an Ox, showing in a remarkable manner the marks of gnawing by rodents, possibly Squirrels, Rats, or Mice, which he had found in the woods near Cromer.

The following papers were read :—

1. Description of a new Form of Ratel (*Mellivora*) from Sierra Leone, with Notes upon the described African Forms of this Genus. By R. I. POCKOCK, F.L.S., F.Z.S., Superintendent of the Gardens.

[Received March 9, 1909.]

(Plate LXI.)

The Society has recently received from Mrs. Bettington a Ratel which not only came from Sierra Leone, a locality whence the genus *Mellivora* has never been previously recorded, but differs markedly in coloration from all the examples that I have seen alive and equally so from all the skins, with one exception, that are contained in the collection of the British Museum.

I propose to describe it as a new species under the name *Mellivora signata*.

MELLIVORA SIGNATA, sp. n. (Plate LXI.)

Forehead and fore part of the nape and sides of the neck quite white, the white on the sides extending farther back than on the upper surface of the neck. In the angle thus defined upon the posterior part of the nape, as well as on the shoulder, the colour is iron-grey, being a mixture of wholly black and wholly white hairs and of black hairs with a pale subapical annulus, the black predominating. Behind the shoulders the prevailing colour of the back is black ticked or speckled with yellowish and brownish grey. None of the hairs of this region appears to be wholly pale as in all other Ratels, except *M. cottoni*; but a considerable number of them have a narrower or broader pale subapical annulus imparting the speckled appearance above described. Over the hind-quarters this speckling gradually dies away; there is, indeed, a gradual but marked decrease in the amount of speckling from the fore part to the hind part of the back, the speckling of the fore part blending with the iron-grey hue of the shoulders and the latter blending to a certain extent with the white of the head and neck, though the angular line of demarcation is very visible. Tail all black. Legs, muzzle, and under parts black, as in all Ratels. Hairs on the sides of the neck showing a tendency to grow forwards and inwards from a whorl on the shoulders, thus forming a weak nuchal crest.

Loc. About 100 miles inland of Sierra Leone.

It was stated above that, with one exception, this specimen, which is not yet adult, differs markedly from all the skins of *Mellivora* in the British Museum. This exception is a piece of the skin of the hind-quarters, flat and native-prepared, which was brought from West Africa by Winwood Reade, together with other material for which no locality was in any case,



Moorepark Lith.

Glebe Press, Imp.

MELLIVORA SIGNATA.

I believe, certainly known. But the vessel in which Reade went to the Gaboon stopped at the Gambia and Sierra Leone*, and it is possible that the skin in question came from the latter place. In any case it seems to belong to the same kind of Ratel as the one I have here described as new, though possibly subspecifically distinct from it. It is markedly dark in colour, being dark brown speckled with dirty yellow. Some of the hairs are dirty yellow throughout; others have a pale annulus of that tint.

Although the marked contrast between the colouring of the head and that of the body distinguishes *M. signata* at a glance from its congeners known to me, a specimen described by Pousargues from the French Congo appears to show a decided approach to it, despite Pousargues' remark that he could establish no difference between this specimen and examples from East and South Africa. He states, however, that the back bears a median iron-grey longitudinal zone, which extends from the middle of the upper side of the neck to the tail and is limited in front by a pure white "calotte" on the nape of the neck and head. It is obvious, however, that this Congoese specimen differs entirely from the one here described in the uniform iron-grey hue of the back, shoulders, and hind quarters.

Mrs. Bettington, who brought this Ratel from Sierra Leone, gave me the following information about it. According to native reports the species is nocturnal and lives to a great extent upon fish, which it catches with its paws at the edge of streams, and the specimen above described preferred fish to meat during the time she had it in captivity. It also showed a liking for bread in preference to meat. She kept it in a yard with some fowls and it never made any attempt to kill them. Thinking from this that it could be trusted with other living animals, she allowed it access one day to some puppies, but these it proceeded to devour without delay. When she put it with an Irish terrier the two merely sniffed each other and parted, although the terrier would on ordinary occasions attack, and if possible kill, any wild animals—such as civets—it came across. This incident has an interesting bearing upon the theory that the Ratel is protected by its scent from attacks by large carnivora, a protection with which is associated what is believed to be the warning characters of its coloration †.

Unfortunately the animal died from a form of "distemper," probably contracted on the voyage, a few weeks after being deposited in the Gardens. Its anal stink-glands resembled in position those of Skunks (*Mephitis*) although smaller. There was a pair of them, each about the size of a thrush's egg, opening upon a papilla or nipple, just within the anal orifice, and lying obliquely backwards deep in the surrounding tissue. The

* See 'Adventures in the Forest and the Field,' by The Old Shikarry (H. A. Leveson), pp. 160-278.

† Pocock, P. Z. S. 1908, pp. 949-951.

external or adanal portion of the gland consisted of spongy tissue traversed by a narrow passage leading to the aperture on the papilla. This no doubt was the secreting area. The internal or adoral portion, on the contrary, formed a hollow semi-oval space, which apparently acts as a reservoir for the storage of the ejectable fluid.

The discovery of this form of *Mellivora* in the Sierra Leone district considerably extends the known geographical range of the genus, which had not been previously recorded to the west of Lake Chad. It was also known to occur in the district between the Niger and the Congo, in the Ituri Forest, and in East and South Africa from Abyssinia and Somaliland to Cape Colony and Angola.

The East and South African Ratels have always been referred to the same species, *M. ratel* Sparrm., of which *M. capensis* Schr., *M. mellivora* G. Cuv., and *M. typicus* A. Sm. are absolute synonyms. There does not seem to have been sufficient material collected in different parts of East Africa to show whether these animals have been differentiated into subspecies distinguishable from typical *M. ratel* or not; but there is no doubt that specimens, from Suakin for example, are very like those from Cape Colony. Judging, nevertheless, from material in the British Museum, it seems that South African specimens have on an average more black hairs in the dorsal pelage and the white marginal line more strongly pronounced than in North-east African examples.

Three distinct species, however, have been described from West African material, namely:—

1. *Mellivora leuconota* P. L. Slater (P. Z. S. 1867, p. 98, pl. viii., and 1871, p. 232). Based upon a young specimen from West Africa which was separated from *M. ratel* on account of the nearly uniform whiteness of its upper side. When adult, the animal exhibited more grey on the posterior region of the back. This change in colour induced Dr. Slater to abandon the species, a conclusion in which he was followed by Pousargues (Ann. Sci. Nat. iii. p. 275, 1896) and by W. L. Slater (Fauna of S. Afr., Mamm. i. p. 110, 1900). P. L. Slater, however, remarked that even the adult animal had the crown white; and his description of the dorsal surface does not fit that of examples of the typical S. African *M. ratel* in the British Museum, which have the head and back dark iron-grey, with a large percentage of black hairs mixed with the white.

W. L. Slater's description of specimens in the Museum at Cape Town, of which he says "general colour above from forehead to base of tail greyish brown, becoming darker posteriorly," further shows that the head is not, so far as is known, white in the typical form. This is also apparently true of an example from Suakin, which presumably formed the basis of the description and figure of this animal in Anderson's and de Winton's 'Mammals of Egypt,' p. 246, 1902.

Pousargues, moreover, as above stated, described a specimen from the French Congo as having the fore part of the neck and the head white and the posterior part of the neck and the back iron-grey. His description indicates a decided contrast between the tints of the head and back. Finally, there is in the British Museum a skin from W. Africa, sent home by Mr. G. L. Bates, probably from the Cameroons or the Benito River, which is uniformly yellow-white from the forehead to the root of the tail, thus resembling the first published description of *M. leuconota*. These facts, coupled with the lack of evidence that the young of typical *M. ratel* is whiter than the adult, induce me to believe that the name *leuconota* should be preserved as a subspecific title for, at all events, one of the Ratels, if there be more than one, from the Congoese area.

2. *M. cottoni* Lydekker (P. Z. S. 1906, i. p. 112, pl. vii.), from the Ituri Forest. Quite distinct from all the previously described Ratels in the absence of white on the dorsal area, the whole animal being black. As Mr. Lydekker suggested, this may be a melanotic sport; but there is no evidence of this up to the present time, only one example being known from the locality.

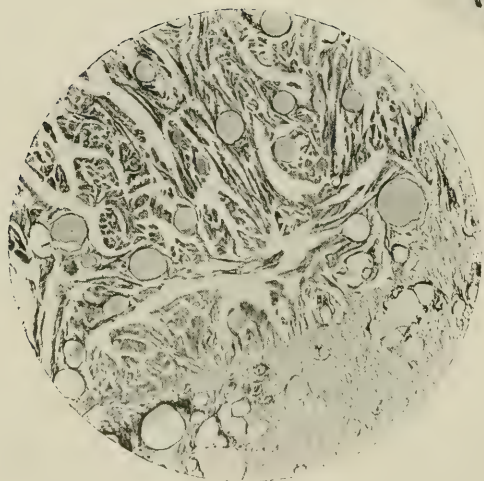
Of the Ratels that I have seen, the one that comes nearest to *M. cottoni* in colour is an example which was purchased by the Society more than nineteen years ago from Cross, of Liverpool, and is still living in the Gardens. Its locality is unknown. It was entered in our books as "*Mellivora capensis*," but the specific name was subsequently altered to "*indica*"—I suppose because there is no whitish band defining the greyish hue of the dorsal surface from the black of the underside, this being formerly regarded as the one distinguishing feature between the African and Indian forms. It is an unusually dark animal, darker, in fact, upon the head and dorsal surface than any that I have seen except *M. cottoni*. These areas are very dark grey, being black merely sprinkled with grey. One of the keepers, however, Hoare, who has known the animal for nearly twenty years, tells me that he thinks it was a good deal greyer when first purchased as a young animal. Another keeper, Dixon, on the contrary, who has looked after it for fifteen years, says that it is the same colour now as when he first took charge of it. However that may be, there is no doubt that at the present time the animal is intermediate in colour between typical *M. ratel* and *M. cottoni*. I cannot determine it more accurately. It may be that the dark hue of the dorsal surface is a sign of age. In favour of this view may be alleged the increase in the dark hue of the dorsal area with advancing years in the type of *M. leuconota*; and the fact that Blanford describes *M. indica* as light grey or whitish grey above, whereas in two Indian specimens in the British Museum, both young animals, one from Nepal and the other from Rajpootana, the dorsal area is almost wholly white. If such a change typically takes place in both African and Indian

Ratels, the fact must be reckoned with in our estimate of the characters of *M. cottoni*, and renders all the more remarkable the very dark coloration of the back in the type of *M. signata*, a quite young animal.

3. *M. concisa* Thomas & Wroughton (Ann. & Mag. Nat. Hist. (7) xix. p. 376, 1907), from Yo, Lake Chad. Separated as a species from *M. ratel* because it is a little smaller and because there is a narrow median longitudinal black area extending from the posterior end of the lumbar region, over the sacral region to the root of the tail, which has no white hairs. The rest of the upper surface is iron-grey, the head being only a little lighter than the back, and there is no distinct white marginal stripe. I find it impossible to give these characters more than subspecific value. Indications of darkening of the sacral region may be seen in skins from E. Africa scarcely separable from typical *M. ratel*; and a skin in the British Museum sent by Capt. Flower from Khartoum presents nearly the same peculiarities in the coloration of the hind-quarters as does the Lake Chad specimen. As for the absence of the white hair from the root of the tail, no great importance, it seems, can be attached to that character, for of two skins in the British Museum, ticketed "Somaliland, R. M. Hawker," one has no white hairs on the base of the tail, whereas in the other the white hairs extend about two inches down that organ. Only one example of *M. concisa* was procured.

I subjoin a table of the named forms of African Ratels, leaving for the present unsettled the question, not a very important one in the present instance, as to the exact systematic rank that should be assigned to them:—

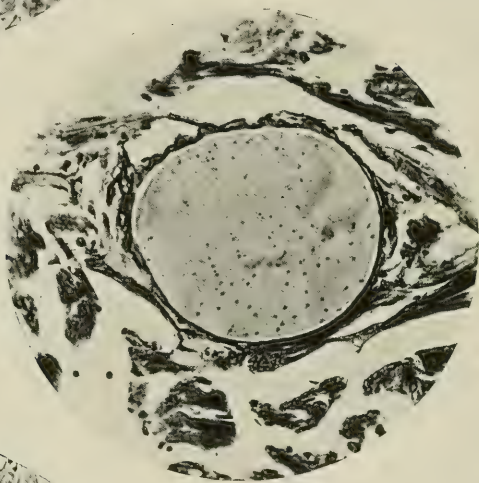
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|--|--------------------------------|
| a. No white hairs upon the head or back | <i>cottoni</i> , Ituri Forest. |
| a'. Head white or iron-grey; a varying amount of grey or dirty white or white on the back. | |
| b. Head and fore part of the neck, especially at the side, white and sharply defined from the rest of the neck and back, on which the black is markedly dominant, very few of the hairs being wholly dirty white, this pale tint being confined to a sub-apical annulus on some of the black hairs | <i>signata</i> , Sierra Leone. |
| b'. Head and fore part of the neck sometimes white, but never apparently very sharply defined by their tint from that of the posterior part of the neck and the body, which are either wholly white or iron-grey, due to a mixture of hairs black or white throughout their length. | |
| c. Head white, back white (? young) or iron-grey ... | <i>leuconota</i> , Congo. |
| c'. Head not white, iron-grey like the back though a little paler. | |
| d. No distinct marginal white band; sacral region mesially black, no white on root of tail | <i>concisa</i> , L. Chad. |
| d'. A distinct marginal white band; hind-quarters uniformly iron-grey at least to the root of the tail | <i>ratel</i> , C. Colony. |



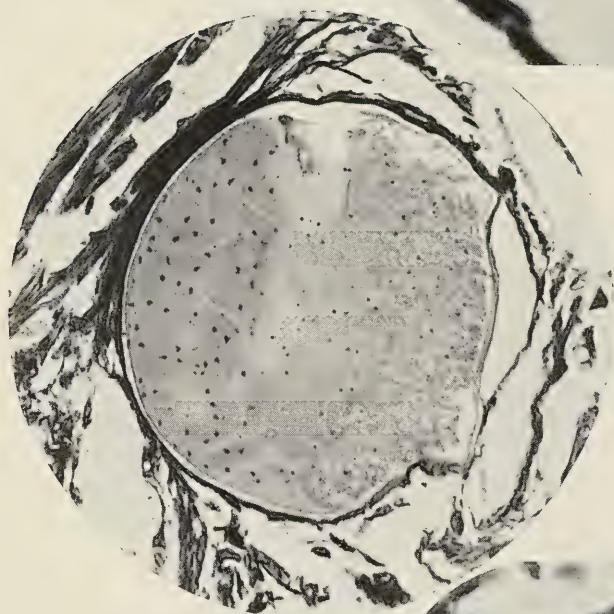
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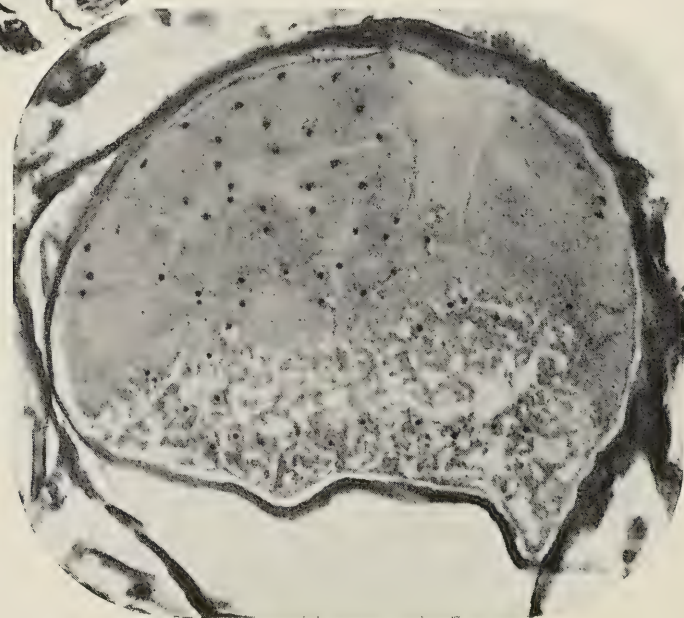
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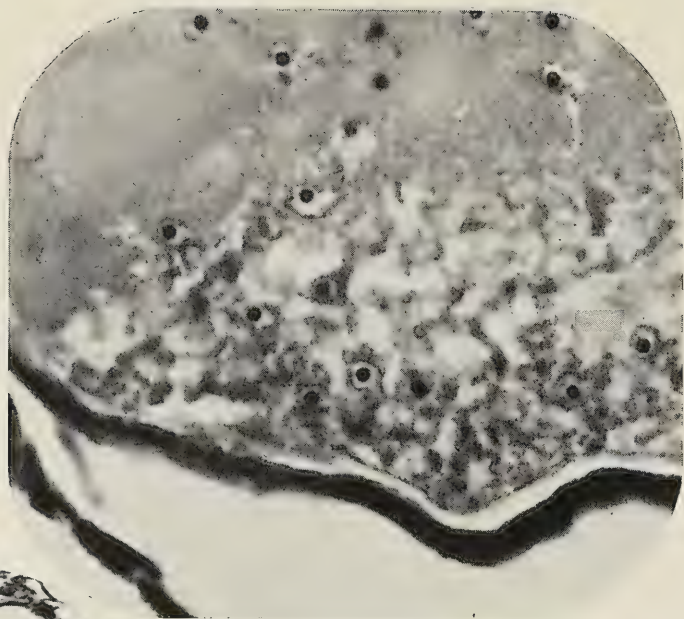
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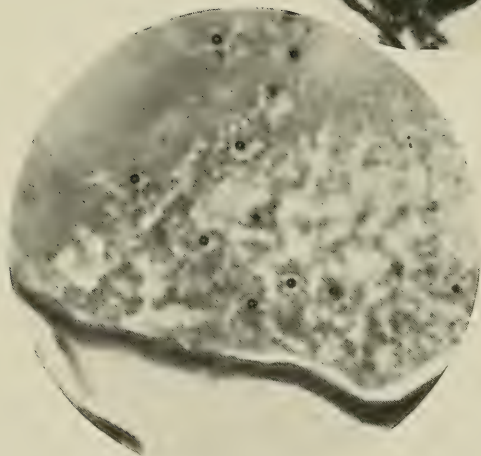
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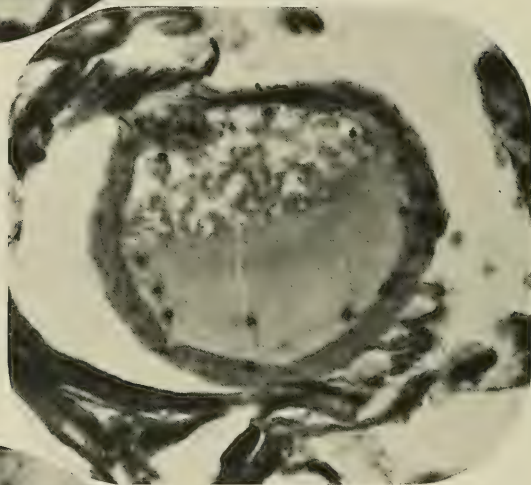
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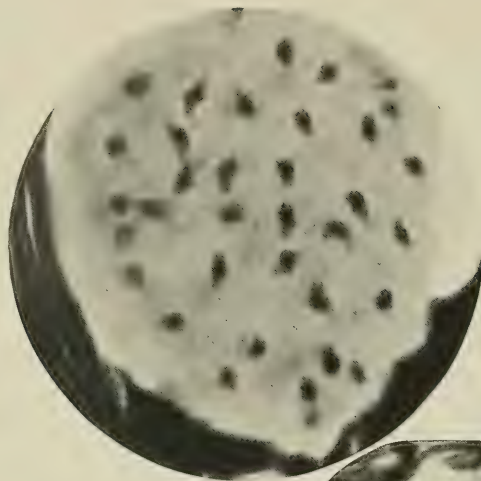
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2. Notes on an *Ichthyosporidian* causing a Fatal Disease in Sea-Trout. By MURIEL ROBERTSON, Carnegie Research Fellow *.

[Received March 1, 1909.]

(Plates LXII.—LXIV.†)

In July 1907 Dr. Turnbull, of the London Hospital Medical School, while fishing on the River Ewe in Ross-shire, observed that a number of sea-trout were affected with a disease which culminated in the death of the fish. Externally they showed nothing abnormal, but on opening them he found that the heart, liver, spleen, and pyloric cæca showed minute sand-like granules.

Dr. Turnbull's description of a typical infection reads as follows:—

“The gills were healthy and showed no adherent parasites.

“The heart: the ventricle was pale, rough and sandy, and minute white granules could be seen. Similar granules were on the auricles and sinus venosus.

“The liver was of a yellow colour and showed minute, yellowish-white, slightly raised, rounded granules on the surface and in section.

“In the spleen very few granules could be detected.

“The alimentary tract was empty and no duodenal tape-worms were present.

“The brain, on removal, showed no abnormalities.

“The ovaries showed no granules.”

Some fish, however, showed an even more complete infection than this; thus in some cases the pyloric cæca, the gills, the submucosa of the œsophagus, the testicles, and the parietal muscles beneath the peritoneum all showed the characteristic sanded appearance.

Dr. Turnbull observed that the diseased sea-trout were all fresh-run fish and were generally of about 4 lbs. weight and over, although one infected fish was got which weighed 2 lbs.

The River Ewe runs from “Loch Maree” into the sea-loch “Loch Ewe” at “Poolewe.” It is a short river, only about a mile and half long.

The various internal organs of some of the infected fish were preserved in methylated spirit, this being the only preserving-fluid obtainable. Sections were made which were sent along with Dr. Turnbull's notes to Prof. Minchin at the Lister Institute. The disease proved to be caused by a Protozoan parasite belonging to the genus *Ichthyosporidium*.

In January 1909 Prof. Minchin handed over to me the material together with his own and Dr. Turnbull's notes, and it

* Communicated by Prof. E. A. MINCHIN, M.A., V.P.Z.S.

† For explanation of the Plates see page 402.

is from these that this account of the parasite has to a large extent been drawn.

The genus *Ichthyosporidium* belongs to the family of the Bertramiidae and to the order of the Haplosporidia. It was created by Caullery and Mesnil in 1905 for the two parasites *Ichthyosporidium gasterophilum* and *Ichthyosporidium phymogenes**.

Ichthyosporidium gasterophilum, which is closely allied to if not identical with the parasite in the sea-trout, is found in *Motella mustela* and *Liparis vulgaris*.

These are both shore-living fishes and inhabit the Fucus-belt. Caullery and Mesnil note that *Motella mustela* (the rockling) was most frequently infected and that the infected fish were all above a certain size. The parasite was found only in the pyloric caeca and the ducts of the glands of the stomach. The authors do not mention if the presence of the *Ichthyosporidium* seriously affected the health of the fish.

The *Ichthyosporidium* of the sea-trout can easily be recognised in sections of the tissues as large spherical or elongated bodies (figs. 1-8). The material only shows the trophical stages of the parasite and the fixation is not quite without reproach.

The parasites are multinucleate organisms, most often spherical in shape and possessing a well-marked outer envelope. They range from large individuals with many hundred nuclei, measuring 120 μ m. in diameter, to small forms with a thin envelope and few nuclei. Individuals with only two nuclei are to be found and some apparently with a single nucleus, but it is difficult to be quite certain of these. They are very rare, and in section-material of this type an error in such a point is very easily made.

The envelope is secreted by the parasite; the inner part is smooth and structureless except for occasional striations (figs. 6 & 7). The outer part of the envelope is often slightly crinkled. The shape of the organism is open to very considerable variation; oval, vermiform, and even irregularly branched forms may be found. These are for the most part individuals which have quitted their original envelope and grown out into the tissues. They seem to secrete a secondary envelope, which is generally rather thin; moreover, this may not extend over the whole animal.

Sometimes these large irregular specimens seem to be breaking up into several daughter individuals by the very simple process of plasmotomy. The products of this process are of very varying sizes. It is a very casual method and does not involve nuclear division—it is, in fact, merely the breaking off of a mass of nucleated protoplasm.

* Caullery and Mesnil, C. R. Soc. Biol. Paris, lviii. (1905) pp. 640-642.

It is impossible to say exactly what brings about the exit from the envelope. It is not a question of size, as quite small specimens may be found fixed at what appears to be the moment of escape.

The nuclei in *Ichthyosporidium* are, relatively speaking, very small and very numerous. They consist each of a single compact mass of chromatin surrounded by a clear space which is bounded by a delicate sharply-defined membrane. Very fine rays pass from the mass of chromatin to the membrane. The mass of chromatin or karyosome is dense and compact, and shows no structure, no matter what the stain used. Iron-hæmatoxylin, Delafield's hæmatoxylin, carm-alum and piconigrosin, picrocarmine and piconigrosin, and Twort's neutral red and light green stain were all tried and all gave very fair results. Iron-hæmatoxylin and Twort's stain, however, gave the best pictures. The rays passing from the karyosome to the outer membrane are exceedingly fine and stain rather faintly with the chromatin stains. The membrane takes up the chromatin colours faintly when stained with iron-hæmatoxylin, Delafield's hæmatoxylin, &c., but takes up the green of the Twort's stain—that is to say, it does not take the chromatin stain of this combination. This is a rather interesting point, as it indicates that whatever its nature it is not the mere condensation of chromatin which generally constitutes the so-called "membrane" in the Protozoa. It may be noted that the red colour in Twort's stain, when properly applied, appears to be a pretty good test for chromatin.

No stages showing nuclear division were observed nor was there any indication of spore-formation.

As has already been stated, the parasite invades practically all the organs of the trout, but seems always to be found in the greatest numbers in the muscles of the heart.

The reaction on the part of the host in the way of forming connective-tissue cysts round the parasites is comparatively slight. In the liver and spleen, it is true, cysts composed of many layers of connective-tissue cells are formed, especially in the case of the larger parasites; but in other parts of the body, such as the heart-muscles, the cysts consist only of two or three thin layers of cells, and may sometimes not be formed at all. The envelope secreted by the parasite in these cases lies in direct contact with the striped muscle-fibres. This relatively slight development of connective tissue may have a certain importance in explaining the fatal nature of the disease.

Three years ago, in January 1906, I came across an *Ichthyosporidium** identical, as far as I can see, with the one found in the trout, in a small flounder (*Pleuronectes flesus*).

The fish was also infected with a trypanosome, which was the parasite I was in search of, and I unfortunately did not examine

* Proc. Roy. Phys. Soc. of Edinburgh, vol. xvii. No. 5, 1903.

the heart. The liver and the submucosa of the stomach and the intestine were very strongly infected, far more so than any of the organs from the trout. This material gave a more complete picture of the trophic life of the parasite. Such points as the multiplication of the nuclei, the exit from the envelope, and the breaking up of the large individuals into numerous small naked bodies with few nuclei were clearly illustrated in the sections. There were, however, no signs of sporogony. In the flounder very large connective-tissue cysts were formed both in the liver and in the alimentary canal. The only difference between the infection in the sea-trout and that in the flounder is in the greater development of connective tissue on the part of the latter host. The flounder in question must ultimately, I should think, have succumbed to the disease, as the liver was in a very pathological condition, but it had been living for some months in captivity in the tanks of the Millport Marine Station and showed no external sign of ill-health.

From the material at my disposal only a very incomplete account of the *Ichthyosporidium* can be given. It is to be hoped that this form, which is interesting both from a purely scientific as well as an economic point of view, will receive further attention from Protozoologists and will be studied under more favourable conditions.

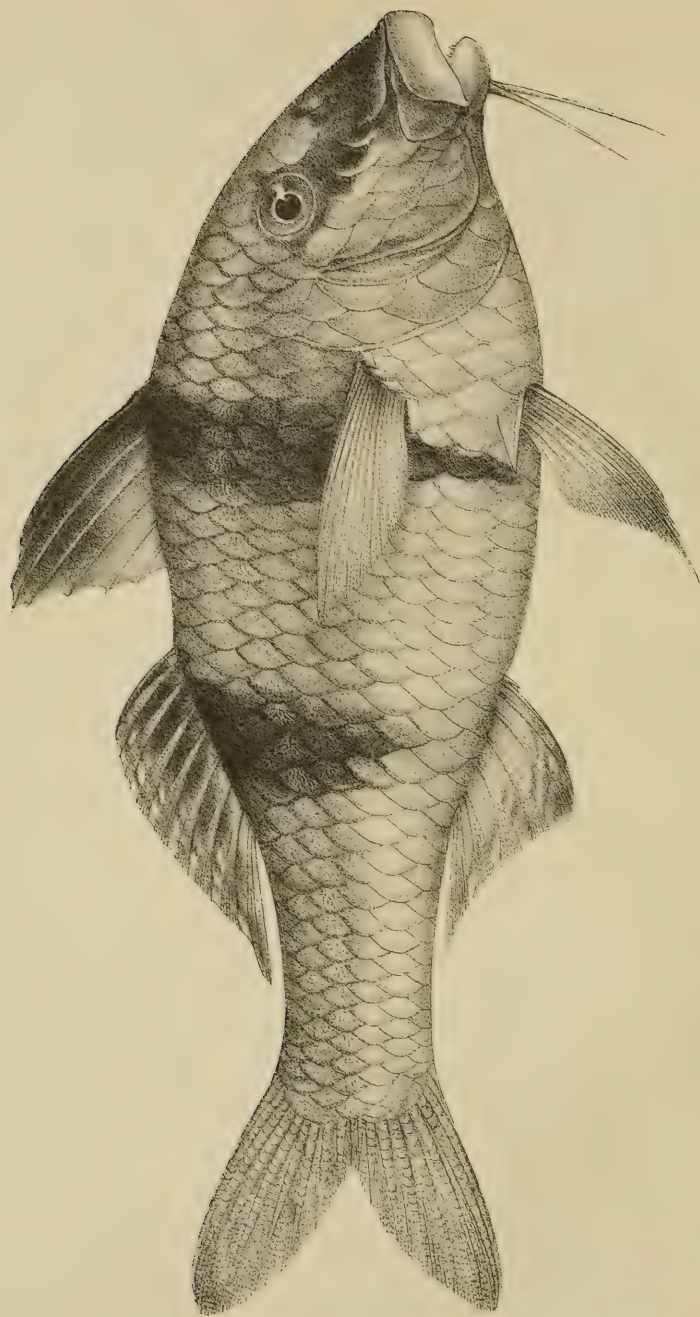
Since writing the above paper another case of the occurrence of this disease has come under my notice in haddocks from Aberdeen. A fishmonger in Glasgow, while cutting the fish into filets, observed minute yellowish white granules in the tissues. He sent the filets to Prof. Graham Kerr, who forwarded them to me at the Lister Institute. It was found that the appearance was due to the presence of an immense number of an *Ichthyosporidian* apparently identical with the one described in this paper.

EXPLANATION OF PLATES LXII.-LXIV.

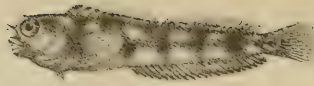
Ichthyosporidians of Sea-Trout.

- Fig. 1. Magn. of 35 diam. Showing general appearance of the parasites in section of the heart.
 2. Magn. of 100 diam. General view of the parasites, showing different shapes assumed.
 3. Magn. of 250 diam. Single large parasite, showing the envelope.
 4. Magn. of 250 diam. Single large parasite; the shrinkage is due to the fixation, as also the appearance of the nuclei at one side. The envelope shows clearly.
 5. Magn. of 500 diam. Shows thin layer of connective tissue round the parasite; envelope of the *Ichthyosporidium* and the nuclei are both shown.
 Figs. 6 & 7. Magn. of 1000 diam. These two figures show the nuclei; the fine rays passing from the karyosome to the membrane can be seen.
 Fig. 8. Magn. of 1000 diam. Shows the nuclei distorted in the process of fixing.
 9. Magn. of 750 diam. Gives another appearance caused by fixation.

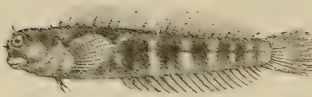
These figures are from untouched photographs kindly executed by Dr. Reid.



PARUPENEUS ANDREWSII.



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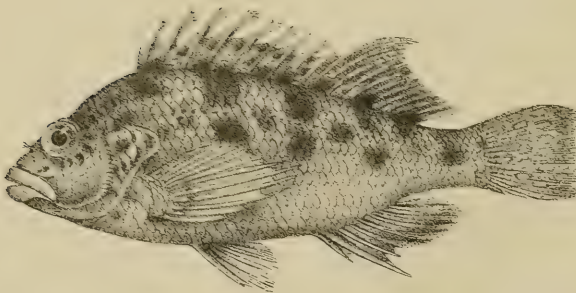
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6

J. Green del. lith. et imp.

1. *BLENNIUS ATROCINCTUS*. 2. *B. NATIVITATIS*.

3. *SALARIAS CAUDOFASCIATUS*. 4. *S. NATALIS*. 5. *S. MELANOSOMA*.

6. *CIRRHITES MURRAYI*.

3. A Collection of Fishes made by Dr. C. W. Andrews,
F.R.S., at Christmas Island. By C. TATE REGAN,
M.A., F.Z.S.

[Received March 4, 1909.]

(Plates LXV. & LXVI.*)

The fishes obtained by Dr. Andrews at Christmas Island are of considerable interest, as they include examples of seven species which appear to be new to science.

1. *MURÆNA NEBULOSA* Ahl.

2. *PLESIOPS MELAS* Bleek.

3. *SPHÆRODON HETERODON* Bleek.

4. *PARUPENEUS ANDREWSII*, sp. n. (Plate LXV.)

Depth of body a little more than the length of head, which is $3\frac{1}{4}$ in the length of the fish. Interorbital region very convex, its width $3\frac{1}{4}$ in the length of head; diameter of eye 6 in the length of head; lips thick; barbels a little more than $\frac{1}{2}$ the length of head; 25 gill-rakers on the lower part of the anterior arch. 31 scales in a longitudinal series; tubules of lateral line much branched. Dorsal VIII, 9; second spine slender, flexible, not stronger than the others; third longest, $\frac{2}{3}$ the length of head; last soft ray moderately produced. Anal I, 7, the spine very small. Pelvics a little longer than the pectorals, $\frac{2}{3}$ the length of head. Caudal peduncle nearly twice as long as deep. Reddish, with two broad blackish vertical bands below the bases of the spinous and soft dorsal fins respectively; snout dark bluish; spinous dorsal blackish; soft dorsal blackish at the base and with somewhat oblique stripes superiorly; anal with similar stripes.

A single specimen, 270 mm. in total length. From allied species with a somewhat similar coloration *P. andrewsii* is distinguished by having the second dorsal spine slender and flexible. Dr. Pellegrin has kindly examined the specimens in the Paris Museum described by Cuvier and Valenciennes as *P. bifasciatus* and *P. trifasciatus*, all of which have a strong, pungent, second dorsal spine †, as have the specimens in the British Museum referred to those species. *P. bifasciatus*, in most respects the nearest to *P. andrewsii*, differs also in that the last ray of the second dorsal is the shortest instead of the longest (Bleek. & Pollen, Faun. Madagasc., Poiss. pl. xviii. fig. 2).

5. *CHELMO LONGIROSTRIS* Brouss.

* For explanation of the Plates see page 406.

† This was clearly seen in Lacepède's type of *P. bifasciatus*.

6. *CIRRHITES MURRAYI*, sp. n. (Plate LXVI. fig. 6.)

Depth of body $2\frac{1}{2}$ to 3 in the length, length of head $3\frac{1}{4}$ to $3\frac{1}{2}$. Snout as long as or longer than eye, the diameter of which is $3\frac{1}{2}$ to 4 in the length of head and about twice the interorbital width. Maxillary extending to below anterior part or middle of eye; anterior nostril with a fringed tentacle; cheek with 4 series of scales. 44 to 46 scales in a longitudinal series. Dorsal X 12; fifth and sixth spines longest, $\frac{1}{2}$ the length of head; interspinous membranes deeply notched, produced into a penicillated lobe behind each spine; first soft ray the longest, about $\frac{3}{4}$ the length of head. Anal III 6; second spine strongest and longest, $\frac{2}{3}$ the length of head. Pectoral with six simple rays. Caudal subtruncate. Reddish, with about 6 blackish vertical bars, each of which is usually broken up into 3 or 4 oblong spots; blackish spots on head and on spinous dorsal fin.

Seven specimens, 64 to 78 mm. in total length; a number of smaller examples are not included in the description. The species is named after Sir John Murray, K.C.B., F.R.S.

I accept the family Cirrhitidae as defined and limited by Dr. Günther, with the addition of *Haplodactylus*. This very natural group is characterized externally by a number of features, amongst which may be mentioned the unbranched lower rays of the pectoral fins and the posterior position of the pelvic fins. Of osteological characters the most notable are the form of the cleithra, which have strong horizontal expansions anteriorly and meet in a long symphysis inferiorly, and the attachment of the well-developed epipleurals at or immediately above the insertion of the ribs. A subocular shelf is present in *Cirrhitès* and *Chilodactylus*, absent in *Chironemus*, *Latris*, and *Haplodactylus*. Parapophyses commence on the first vertebra in *Latris*, *Haplodactylus*, and *Chilodactylus*, on the third or fourth in *Chironemus*, and on the fifth or sixth in *Cirrhitès*.

7. *GLYPHIDODON SORDIDUS* Rüpp.8. *PLATYGLOSSUS HYRTILII* Bleek.9. *PTEROIS VOLITANS* Linn.10. *CARACANTHUS UNIPINNA* Gray.11. *GوبيUS ALBOPUNCTATUS* Cuv. & Val.12. *TRIPTERYGIUM ATROGULARE* Günth.13. *BLENNIUS NATIVITATIS*, sp. n. (Plate LXVI. fig. 2.)

Depth of body nearly equal to length of head, about 5 in the length of the fish. Snout vertical; maxillary extending to below posterior edge of eye; a pair of posterior canines in the lower

jaw; tentacles all simple, the nasal and nuchal pairs short, the ocular pair longer; no crest on the head. Dorsal XII 15; notch rather deep; last ray not connected with the caudal. Anal 18-20. Caudal rounded or subtruncate. Reddish, with about 8 darker cross-bars, sometimes appearing only as a series of oblong blotches along the middle of the sides; fins pale.

Several specimens, measuring up to 45 mm. in total length.

14. *BLENNIUS ATROCINCTUS*, sp. n. (Plate LXVI. fig. 1.)

Depth of body nearly equal to the length of head, about 5 in the length of the fish. Snout vertical; maxillary extending to below middle of eye; no canines; nasal and orbital tentacles bifid; no nuchal tentacles; no nuchal crest. Dorsal XIII 17; first three rays rather wide apart; notch rather deep; last ray not connected with the caudal. Anal 22. Caudal rounded or subtruncate. Reddish, with 6 blackish cross-bars continued on to the basal part of the dorsal fin; anal blackish.

A single specimen, 27 mm. in total length.

15. *SALARIAS HASSELTII* Bleek.

16. *SALARIAS CAUDOFASCIATUS*, sp. n. (Plate LXVI. fig. 3.)

Allied to *S. marmoratus* Benn. Depth of body a little less than the length of head, $\frac{1}{5}$ the length of the fish. Snout vertical; maxillary extending to below posterior edge of eye; a pair of posterior canines in the lower jaw; nasal and orbital tentacles fringed; a pair of short, simple nuchal tentacles; no crest. Dorsal XII 15; anterior portion low; second portion elevated, with the rays decreasing in length from the first; last ray not joined to the caudal. Anal 18. Caudal subtruncate. Reddish, with scattered pale spots and with 6 dark cross-bars, each of which is split into two; caudal with dark vertical bars; anal dusky.

A single specimen, 55 mm. in total length.

17. *SALARIAS NATALIS*, sp. n. (Plate LXVI. fig. 4.)

Allied to *S. unicolor* Rüpp. Depth of body equal to or less than the length of head, $5\frac{1}{4}$ to 6 in the length of the fish. Snout vertical; maxillary extending to below posterior edge of eye or beyond; a pair of posterior canines in the lower jaw; nasal tentacles simple or fringed; orbital tentacles rather long, fringed; no nuchal tentacles; an occipital crest. Dorsal XII-XIII 17-18; notch deep; last ray not joined to the caudal. Anal 20-22. Caudal subtruncate or rounded. Head and body with 14 purplish cross-bars arranged in pairs and usually split up to form 3 longitudinal series of spots; fins dusky, the dorsal with oblique stripes.

Eleven specimens, measuring up to 60 mm. in total length.

18. *SALARIAS MELANOSOMA*, sp. n. (Plate LXVI. fig. 5.)

Allied to *S. anomalus* Regan (Journ. Bombay Nat. Hist. Soc. xvi. 1905, p. 327, pl. ii. fig. 4), but with the nasal tentacles double or even triple, one or sometimes two shorter tentacles originating at the base of the longer one. Dorsal XII 17, the spines not produced, the longest not more than $\frac{1}{2}$ the depth of the body. Anal 20. Caudal truncate or slightly trilobed. Blackish or dark brownish; middle rays of caudal dusky.

Six specimens, measuring up to 60 mm. in total length.

The presence of posterior canines in the lower jaw led me to re-examine *S. anomalus* and I find they are present, but often hidden by a fleshy fold.

19. *BROTULA MULTIBARBATA* Schleg.20. *BALISTES RECTANGULUS* Bl. Schn.21. *DIODON HYSTRIX* Linn.

EXPLANATION OF THE PLATES.

PLATE LXV.

Parupeneus andrewsii.

PLATE LXVI.

- Fig. 1. *Blennius atrocinctus*.
 2. „ *nativitatis*.
 3. *Salarias caudofasciatus*.
 4. „ *natalis*.
 5. „ *melanosoma*.
 6. *Cirrhites murrayi*.

4. On some New and Little-known *Hesperiidae* from Tropical West Africa. By HAMILTON H. DRUCE, F.L.S., F.Z.S.

[Received March 16, 1909.]

(Plate LXVII.*)

Amongst a collection of Lepidoptera obtained in the Cameroons, I have been able to distinguish 74 species of *Hesperiidae*, including those described in this paper. Professor Aurivillius has recorded 62 in his list of Butterflies from the Cameroons (Ent. Tidsk. 1896, pp. 279-291), and the following species are not referred to by him, 32 in all, making about 100.

Types of new species in Mus. Druce.

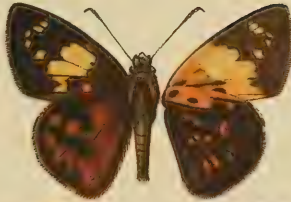
* For explanation of the Plate see p. 413.



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Horace Knight del. et lith.

West, Newman chr.

<i>Celœnorhinus nigropunctata</i>	<i>Parnara fatuellus</i> Hopff.
B.-Baker.	„ <i>noctula</i> , sp. n.
<i>Ortholexis hollandi</i> , n. n.	„ <i>palocampta</i> , sp. n.
<i>Sarangesa brigidella</i> Plötz.	„ <i>flavifasciola</i> , sp. n.
„ <i>bouvieri</i> Mabilie.	<i>Pardaleodes incerta</i> Snellen.
„ <i>perpaupera</i> Holland.	„ <i>bule</i> Holland.
<i>Abantis elegantula</i> Mabilie.	„ <i>astrape</i> Holland.
„ <i>efulensis</i> Holland.	„ <i>ligora</i> Hew.
„ <i>ja</i> , sp. n.	„ <i>vibius</i> Hew.
„ <i>lucretia</i> , sp. n.	<i>Ceratrachia dimidiata</i> Heron.
<i>Hesperia spio</i> Linn.	<i>Andronymus leander</i> Plötz.
<i>Acleros olaus</i> Plötz.	<i>Cænides kanguensis</i> Holland.
„ <i>sparsum</i> , sp. n.	„ <i>leonora</i> Plötz.
<i>Rhopalocampta bixæ</i> Linn.	„ <i>dacena</i> Hew.
„ <i>unicolor</i> Mabilie	„ <i>lacida</i> Hew.
„ <i>hanno</i> Plötz.	„ <i>zaremba</i> Holland (nec Plötz).
<i>Osmodes adon</i> Mabilie.	„ <i>laterculus</i> Holland.
<i>Parnara arela</i> Mabilie.	„ <i>ilerda</i> Möschl. ?
„ <i>subochracea</i> Holland.	„ <i>cerymica</i> Hew.
„ <i>leucophea</i> Holland.	
„ <i>borbonica</i> Boisd.	

CELÆNORHINUS NIGROPUNCTATA. (Plate LXVII. fig. 11.)

Celœnorhinus nigropunctata Bethune-Baker, Ann. & Mag. Nat. Hist. ser. 8, vol. ii. p. 478 (1908).

I have figured a specimen from Bitje, Ja River, Cameroons, which is identical with Mr. Bethune-Baker's type from Makala, Congo Free State. It is much like *C. rutilans**, but the fore wings are shorter and differently marked.

ORTHOLEXIS MELICHOPTERA. (Plate LXVII. fig. 1.)

Ortholexis melichroptera Karsch, Ent. Nach. 1895, p. 320, ♂; Aurivillius, Ent. Tidskr. 1896, p. 288, ♀.

Both Herr Karsch and Professor Aurivillius record this species from the Cameroons. I have figured a female obtained at Bitje, Ja River, from the same district, by Mr. G. L. Bates, in the dry season (2000 feet). It is apparently unknown to M. Mabilie, as he does not mention it in his "*Hesperidae*" in 'Genera Insectorum.' Dr. Holland's genus *Acallopestes* (P. Z. S. 1896, p. 95) seems very nearly related, but the figure and description of the antennæ do not agree. Unfortunately we do not possess either of the species he places in it; neither are they in the British Museum.

ORTHOLEXIS HOLLANDI, nom. nov.

Katreus johnstoni Holland, Ent. News, v. pl. i. fig. 8 (nec Butler).

* *Pardaleodes rutilans* Mab. Bull. Soc. Zool. France, 1877, p. 235.

Hab. Bitje, Ja River, Cameroons, 2000 feet (*G. L. Bates*). Dry season. Upper Kasai District, Congo Free State (*C. Landbeck*).

Professor Aurivillius seems to have been the first to notice that Dr. Holland had "initiated a remarkable error in respect to this form" [Ent. Tidskr. 1896, p. 288] in figuring it as *Katreus johnstoni* Butler. It is, however, possible that Dr. Holland considered it to be the male of that species, but he gave no descriptive account of the insect. The type of *Choristoneura johnstoni* Butler is a male, and is slightly darker than females in the British Museum, and has a small clear shining patch near the base of the fore wing below, but otherwise the sexes are similar.

We have one male from Bitje and three males from the Congo, but I have not seen the female.

In the form of the antennæ and the palpi, and also in the venation, this insect agrees well with *Ortholexis melichroptera*, of which I was inclined to think it was the male. The short subapical fascia is semihyaline white, and the upper surface of both wings has a slight flush of blue. The cilia of the hind wing on both surfaces is whitish, that of the fore wing being colorous with the wings. The palpi and legs are bright yellow.

M. Mabille places the genera *Katreus* and *Choristoneura* widely apart in his "*Hesperidae*" (1904), although Mr. Heron, as long ago as 1898 (Ann. & Mag. Nat. Hist. (7) i. p. 182), has written that they are synonymous.

ABANTIS JA, sp. n. (Plate LXVII. fig. 2.)

Male. Upper side allied to *A. elegantula* Mabille; fore wing coloured as in that species, and with the four discal and three subapical hyaline spots arranged likewise. Hind wing with the outer marginal third paler than median area, and with the basal area whitish hyaline crossed by the black nervules. Cilia dark glistening brown. Under side: both wings greyish buff, palest along the inner margin of fore wing and abdominal fold of hind wing, with black veins and hyaline spots as above. Thorax black, with the convergent tufts of hair brick-red. Abdomen greyish, with a central dark line above and broadly pale buff below. Venter dark brown. Antennæ black. Palpi black above with a white spot; yellow below, terminal joint black. Legs yellow.

Expanse $1\frac{7}{10}$ inch.

Hab. Bitje, Ja River, Cameroons, 2000 feet (*G. L. Bates*). Dry season.

Distinguished at once from *A. elegantula** by the hyaline basal area on the hind wing and by the absence of the yellow basal suffusion on the hind wing above and the unicolorous hind wing below, the basal and discal areas of *A. elegantula* being white on that wing.

* *Abantis elegantula* Mab. Ann. Soc. Ent. France, 1890, p. 32; Novit. Lepid. p. 23, pl. iii. fig. 6 (1891).

Mr. Bates captured specimens of *A. elegantula* in both the dry and the wet seasons, but they show no difference in coloration or size.

ABANTIS LUCRETIA, sp. n. (Plate LXVII. fig. 3.)

Male. Upper side: fore wing dull blackish brown, with three subapical and a discal series of four white spots much as in *A. elegantula*, the upper cell-spot being, however, very minute, almost obsolete. The nervules are darker than the ground-colour. At the base of the wing, placed between the median and submedian nervules, is a dull red patch merging into the ground-colour. Hind wing blackish brown, crossed from the costa, which is orange, to the abdominal fold, which is black, by a broad pure white band, which is sharply defined basally, but which has its outer edge irregular on account of the black nervules reaching beyond its border. An anteciliary row of white spots towards the anal angle. Under side as above but paler; fore wing without the dull red patch at the base. Hind wing with the costa pale brown, a black dash at the origin of the subcostal nervure, and the anal area broadly black. White spots on the collar and the end of the patagia. Abdomen white, with a central black streak above and a black streak on either side below. Venter blackish. Antennæ black; legs yellow; palpi black above, yellow below, terminal joint black. Cilia above and below concolorous with wings except towards anal angle, where it is tipped with glistening white.

Expanse $1\frac{1}{2}$ inch.

Hab. Bitje, Ja River, Cameroons, 2000 feet (*G. L. Bates*). Wet season.

I have named this insect, which is not close to any described in the genus, after *Pseudacreea lucretia* Gr.*, to which it bears a close colour resemblance, and of which specimens were contained in the same collection.

ABANTIS EFULENSIS.

Abantis efulensis Holland, P. Z. S. 1896, p. 21, pl. v. fig. 12, ♂.

Male. Upper side: ground-colour paler than in male; white areas of hind wing almost obsolete, being reduced to a short streak at end of cell and a small patch at anal angle. Under side as male, but slightly paler. Abdomen, which has the base of each segment black, is yellowish brown above and white below.

Hab. Bitje, Ja River, Cameroons, 2000 feet (*G. L. Bates*). Dry season.

A male taken at the same time and place has the abdomen white above and below, with the base of each segment black, in this respect only not agreeing well with Dr. Holland's figure, which is doubtless taken from a stained specimen.

* *Papilio lucretia* Cramer, Pap. Ex. i. t. 45. figs. C, D (1779).

ACLEROS SPARSUM, sp. n. (Plate LXVII. fig. 4.)

Male. Upper side: both wings uniform blackish brown, fore wing without markings, hind wing with the anal angle and outer margins almost to the apex irregularly pure white. Under side: fore wing blackish brown, with the apex and outer margin laved with white and grey, darkest along the costa. Hind wing laved with grey and white, whitest towards the base of the costa and at the anal angle. Thorax black above, white below. Abdomen black above, white towards anus and white below. Palpi: first joint white, second joint white at the base then buff interspersed with black, terminal joint black. Legs black and white, spurs white. The antennæ are black, with the usual pure white spot just before the apex.

Expanse $1\frac{2}{5}$ inch.

Hab. Bitje, Ja River, Cameroons, 2000 feet (*G. L. Bates*). Dry season.

Described from two specimens.

This is a large species, and is perhaps nearest to *A. leucopyga* Mabille*, originally described from Madagascar, but found to also inhabit W. Africa, but has less white on the hind wing above and is differently marked below.

ACLEROS KASAI, sp. n. (Plate LXVII. fig. 5.)

Female. Upper side light brown with whitish hyaline spots. Fore wing: three minute spots placed in a line from the costa, the lower one being the largest, about halfway between the end of the cell and the apex. Two spots in the cell at the end placed one above the other; a spot between the two lower median nervules and a smaller spot above and resting on the submedian nervure about its middle. Cilia brown. Hind wing with a distinct double spot forming a triangle towards the end of the cell. Anal angle, outer margin, and cilia pure white. Under side—Fore wing: costa rusty brown, discal area brown, spots as on upper side, outer margin with a pale pinkish-brown patch below the apex. Central inner marginal area broadly whitish. Cilia pale brown. Hind wing laved with pinkish brown, with darker shadings at the apex and along the inner margin. An outer marginal row of darker brown shades. Cell-spot as above, brown-edged. Anal angle white. Cilia white. Abdomen brown above, with the ventral half pure white; white below. Antennæ brown, with the usual white spot on the club just before the tip.

Expanse $1\frac{1}{2}$ inch.

Hab. Upper Kasai District, Congo Free State (*P. Landbeck*).

This is a large species, not very closely allied to any which I can find described. The clear spots on the fore wing and the distinct central spot on the hind wing at once distinguish it.

* *Cyclopidides leucopyga* Mabille, Bull. Soc. Ent. France, 1877, p. 101.

GORGYRA AFIKPO, sp. n. (Plate LXVII. fig. 6.)

Male. Allied to *G. aburæ* Plötz*. Upper side: ground-colour blackish brown with whitish hyaline spots. Fore wing: a subapical series of three minute dots, the innermost placed further inwards, an elongated spot in the cell near the end, and a smaller, more circular spot above it. A series of four discal spots placed between the nervures nearest their origins, the lower one resting on the submedian nervure about its middle. Hind wing with a large ✓-shaped spot in the cell and two large spots rather beyond the centre of the disc divided by the lower median nervure. The patch of hairs on vein 1b is grey. Under side: hyaline spots as above; fore wing with the apex and outer margins washed with greyish. Hind wing grey, with black spots arranged as in *G. aburæ* but much larger. Thorax and abdomen concolorous with wings. Palpi pale straw-colour below, black above, terminal joint black. Legs brown; fore coxæ clothed with thick straw-colour hairs. Antennæ black.

Expanse $1\frac{1}{2}$ inch.

Hab. Afikpo, N. Nigeria (*Reddick*).

Unlike *G. aburæ* this insect bears but one pair of spurs on the hind tibiae. In general appearance it seems to be much like some species of the genus *Gastrochaeta* Holland, viz. *G. mabiliei* Holland† and *G. cybeutes* Holland‡, but the palpi prove it to belong to *Gorgyra*.

I have shown this insect to M. Mabilie, who states it is quite unknown to him.

PARNARA NOCTULA, sp. n. (Plate LXVII. fig. 7.)

Male. Upper side: both wings unicolorous dark bronze-brown without markings. Cilia concolorous with wings. Under side as above. Head, thorax, and abdomen dark brown; after part of thorax and base of abdomen clothed with dark green hairs. Legs dark brown. Palpi thickly clothed with black and white hairs. Antennæ black, tips chestnut-brown.

Expanse $1\frac{1}{2}$ inch.

Hab. Bitje, Ja River, Cameroons, 2000 feet (*G. L. Bates*). Dry season.

The total absence of markings should distinguish this from all other described species of *Parnara*.

PARNARA PALOCAMPTA, sp. n. (Plate LXVII. fig. 8.)

Female. Upper side: both wings uniform dark brown without markings. Cilia of fore wing concolorous with wings; cilia of hind wing from apex to anal angle whitish. Under side as above. Head, thorax, abdomen, and legs blackish brown.

* *Apaustus aburæ* Plötz, S. e. Z. vol. xl. p. 359 (1879), MS. drawings pl. 736. Holland, P. Z. S. 1896, pl. ii. fig. 18, as *Katreus johnstonii* Butler, error.

† *G. mabiliei* Holland, Ent. News, vol. v. p. 28, pl. i. figs. 15, 16 (1894).

‡ *G. cybeutes* Holland, Ent. News, vol. v. p. 94, pl. iii. fig. 15 (1894).

Palpi thickly clothed with black and white hairs. Antennæ black, excepting tips and outer half of club, which are chestnut-brown.

Expanse $1\frac{7}{10}$ inch.

Hab. Bitje, Ja River, Cameroons, 3000 feet (*G. L. Bates*).

Dry season.

This insect in coloration and shape is very much like a small specimen of *Rhopalocampa unicolor* Mabilles*, which we have received from the same locality, but an examination of the palpi proves that it is not congeneric with that species. The fore wings are more elongated and the hind wings are less produced posteriorly than in most species of *Parnara*. It seemed possible that this might be the female of the previously described *Parnara noctula*, but besides the white fringe on the hind wing and the different shape of the wings the antennæ present considerable differences—they are shorter, the shaft is stouter, and the club more graduated.

PARNARA FLAVIFASCIOLA, sp. n. (Plate LXVII. fig. 9.)

Male. Allied to *P. tarace* Mabilles†. Fore wing dark bronze-brown, with a central row of irregular white spots arranged as in that species. Hind wing with the central yellow fascia broader and without the yellow basal spot. Under side:—Fore wing: ground-colour paler and with spots as above; hind wing much like that of *P. statirides* Holland‡, but yellow area rather less extensive and base clouded with brown. Head black, with a yellow central streak and yellow around the eyes. Thorax brown. Abdomen brown above, yellow below, and with a yellow band at the anus; venter brown. Legs brown with yellow hairs. Palpi black above, yellow below, terminal joint black. Antennæ black, tips yellow.

Expanse $1\frac{1}{2}$ inch.

Hab. Bitje, Ja River, Cameroons, 2000 feet (*G. L. Bates*).

Dry season.

There is a specimen in the British Museum from Sierra Leone from the Crowley Bequest.

PARNARA ARELA.

Hypoleucis arela Mabilles, C. R. Soc. Ent. Belg. xxxv. 1891, p. lxix.

Baoris arela Holland, P. Z. S. 1896, p. 68, pl. ii. fig. 20.

Ceratrachia paucipunctata Bethune-Baker, Ann. & Mag. Nat. Hist. ser. 8, vol. ii. p. 481 (1908).

Mr. Bethune-Baker has shown me his type, which is without doubt a male specimen of this common species with the antennæ wanting.

* *Ismene unicolor* Mabilles, Ann. Soc. Ent. France, (5) vol. vii. p. xxxix (1877).

† *Pamphila tarace* Mabilles, C. R. Soc. Ent. Belg. vol. xxxv. p. clxxix (1891); Novitates Lepid. p. 114, pl. xvi. fig. 1 (1893).

‡ *Baoris statirides* Holland, P. Z. S. 1896, p. 69, pl. v. fig. 6.

PARDALEODES BULE.

Pardaleodes bule Holland, P. Z. S. 1896, p. 76, pl. iii. fig. 21, ♂ ♀.

Pardaleodes makala Bethune-Baker, Ann. & Mag. Nat. Hist. ser. 8, vol. ii. p. 480 (1908).

Mr. Bethune-Baker's type, which he has kindly shown me, does not differ in any way from Dr. Holland's excellent figure.

We have several specimens collected by Mr. G. L. Bates at Bitje, Ja River, Cameroons.

CERATRICHIA IALEMIA, sp. n. (Plate LXVII. fig. 10.)

Male. Allied to *C. nothus* Fab.* Upper side uniform dark brown, with 5 or 6 minute white spots beyond the cell on the fore wing. Under side: fore wing much as in *C. nothus*; hind wing white, with 5 small brown discal spots and outer margin broadly clouded with dark brown enclosing a submarginal series of 5 round spots with paler centres. Thorax and abdomen brown above, white below. Legs white. Palpi yellow with black hairs.

Female. Upper side as male, but white spots larger and with two extra in the discal series towards the inner margin, and a white spot in the cell of the fore wing. Under side: fore wing marked as above; hind wing as in male.

Expanse $1\frac{3}{10}$ inch.

Hab. Bitje, Ja River, Cameroons, 2000 feet (*G. L. Bates*). Dry and wet seasons.

This insect has the hind wing below quite differently marked from *C. nothus*, which is very near to the figure given by Dr. Holland of *Hypoleucis enantia* Karsh, P. Z. S. 1896, pl. ii. fig. 17. M. Mabille in Wytsman's Hesperidæ still places *enantia* in the genus *Hypoleucis*.

EXPLANATION OF PLATE LXVII.

- Fig. 1. *Ortholexis melichroptera* Karsch, p. 407.
 2. *Abantis ja*, sp. n., p. 408.
 3. " *lucretia*, sp. n., p. 409.
 4. *Acleros sparsum*, sp. n., p. 410.
 5. " *kasai*, sp. n., p. 410.
 6. *Gorgyra afikpo*, sp. n., p. 411.
 7. *Parnara noctula*, sp. n., p. 411.
 8. " *palocampta*, sp. n., p. 411.
 9. " *flavifasciola*, sp. n., p. 412.
 10. *Ceratruchia ialemia*, sp. n., p. 413.
 11. *Celænorhinus nigropunctata* B.-Baker, p. 407.

* *Papilio nothus* Fab. Mant. Ins. p. 88. n. 799 (1787).

April 27th, 1909.

Prof. E. A. MINCHIN, M.A., Vice-President,
in the Chair.

The Secretary read the following report on the additions made to the Society's Menagerie during the month of March 1909 :—

The number of registered additions to the Society's Menagerie during the month of March last was 157. Of these 96 were acquired by presentation, 21 by purchase, 28 were received on deposit, and 12 were born in the Gardens.

The number of departures during the same period, by death and removals, was 135.

Amongst the additions special attention may be directed to :—

One White-headed Ratel (*Mellivora signata*), from Sierra Leone, new to the Collection, deposited on March 1st.

One Eland (*Taurotragus oryx*) ♂, from South Africa, presented by Vice-Admiral Sir Percy Scott, K.C.V.O., on March 9th.

One Eland (*Taurotragus oryx*) ♀, born in the Menagerie on March 17th.

One Tasmanian Wolf (*Thylacinus cynocephalus*) ♀, from Tasmania, purchased on March 12th.

Two King Birds of Paradise (*Cicinnurus regius*) ♂ ♀, from New Guinea, purchased on March 23rd.

One South-African Harrier (*Circus ranivorus*), one Booted Eagle (*Nisaetus pennatus*), and fifty-four Millipedes belonging to two species (*Archispirostreptus pyrocephalus* and *A. cristulatus*), from Port Elizabeth, presented by A. W. Guthrie, Esq., F.Z.S., on March 20th.

Three Hercules Beetles (*Dynastes hercules*), from Dominica, new to the Collection, presented by T. Laurance Eve, Esq., on March 31st.

Mr. H. F. McShane exhibited a series of lantern-slides of animals living in the Society's Gardens.

Prof. E. A. Minchin, M.A., V.P.Z.S., exhibited living specimens of eggs, larvæ, and adults of the tick *Ornithodoros monbata* Murray. This tick lives in the mud floors of human habitations and encampments in many parts of Africa, and is the means of transmitting the spirochæte which causes African Relapsing Fever (*Spirochæta duttoni*). The specimens shown were collected and sent home by Sir David Bruce, from Uganda, and were probably infected.

Mr. R. H. Burne, F.Z.S., exhibited a series of specimens from the Museum of the Royal College of Surgeons, showing (1) the different mechanisms for the movement of the nictitating

membrane, (2) the coarse anatomy of the tapetum lucidum, (3) the organ for elevating the eyes in the Plaiice.

Mr. R. I. Pocock, F.L.S., F.Z.S., the Superintendent of the Gardens, exhibited the photographs of two Quaggas, more commonly called Burchell's Zebras, which were recently imported from Zululand by Herr Reiche, to whom Mr. Pocock was indebted for the photographs. He remarked :—

“These two photographs represent two distinct races of the Quagga, using that term in its broad and correct sense*, both of special interest. The first (text-fig. 48) belongs to the race described by Gray as *Equus burchelli*, which should be called Burchell's

Text-fig. 48.



Burchell's Quagga (*Equus quagga burchelli*).

Quagga (*Equus quagga burchelli*). Very few examples of this race appear to be in existence, either as living animals or museum specimens. In a wild state it is either verging on extinction or wholly extinct. It was originally recorded from British Bechuanaland, and there seems to be no reliable evidence of its occurrence elsewhere. No great importance can be attached to the fact that the specimen in question is alleged to have come from Zululand, because, as the photograph shows, the animal wears a head-stall

* Pocock, Ann. Mag. Nat. Hist. (7) x. p. 306, 1902.

and has obviously been tamed, and may have been transported to various places in South Africa. A point to be noticed in the photograph is the wavy nature of the stripes on the hind-quarters and the unusually marked indication they show of the tendency to break up into spots, which is carried to a greater extreme in the typical Quagga. Shadow-stripes are just traceable up to the withers, and a few well-defined ones are observable on the neck close to the mane.

"This animal supplies one more link in the chain of evidence showing that the true Quaggas and so-called Burchell's Zebras are but local races of one and the same species.

"Similarly the second photograph (text-fig. 49) shows an animal almost intermediate in pattern between Burchell's Quagga and

Text-fig. 49.



Wahlberg's Quagga (*Equus quagga wahlbergi*).

Chapman's Quagga, and supplies a stumbling-block in the way of those zoologists, if any remain, who hold that a specific distinction exists between *E. quagga burchelli* and *E. quagga chapmani*. The animal depicted is a specimen of the little-known Wahlberg's Quagga (*E. quagga wahlbergi*), which I described some years ago

from a specimen from Zululand in the British Museum. It is not exactly like the type, but is near enough to leave little doubt as to their subspecific identity. It differs from Burchell's Quagga in being striped, though sparsely, on the outsides of the legs and on the hind-quarters up to the root of the tail, and in the extension of the body-stripes to the median ventral line. The stripes are all rather thin, and are especially thin and faint on the area below a line joining the stifle-joint and the root of the tail. On the lower half of the thigh, on the left side, they form a more or less reticulated pattern, as has been already recorded in the case of the example of this race in Mr. Rothschild's Museum at Tring*. On the thigh of the right side the stripes form no such reticulation. Shadow-stripes are well developed and extend as far as the withers, as in the typical specimen. There are indications of them also on the neck. Since Zululand is known to have been the home of Wahlberg's Quagga, there is no reason to doubt that the specimen under discussion came from that country.

"In connection with these photographs attention may be drawn to a point connected with the pattern of these and more northern races of Quaggas, which I believe has a procrystic significance not previously noticed. This is the sharp division of the body by the direction of its stripes into an anterior and a posterior half. On the shoulders and fore part of the body the stripes are vertical; but on the hinder half of the body and quarters they abruptly take an oblique direction backwards. The optical effect this change of direction in the stripes has upon me is that of two distinct objects in the line of vision instead of one; each object is in itself incomplete, and the resemblance of the two combined to the body of an animal shaped like a uniformly-coloured horse tends to be destroyed. This obliteration of the horse-like form is still further effected by the nature of the stripes on the posterior half of the neck, which are not only broader than those on the withers and shoulders, but when the neck is carried in its usual position, incline at a different angle from them. Coming finally to the head, it is noticeable that there is a further change in the stripes, which are not only narrow but vary in direction, the direction being to a great extent different from that of the neck-stripes. As for the legs, they are either unstriped in Quaggas or striped in a direction parallel to the long axis of the body. Thus setting aside the legs, a Quagga of the type above discussed, of which any one of the subspecies would do as an example, is broken up by the size and direction of its stripes into four distinct blocks or areas, namely, the head, the neck, the shoulders and fore part of the body, the hinder part of the body and the hind-quarters. The optical disruption of the equine form caused by the continuity of narrowly striped and broadly striped areas depends upon the fact that the broadly striped areas appear to be nearer the observer than the narrowly striped areas. They seem to be two objects

* Pocock, Ann. Mag. Nat. Hist. (6) xx. p. 45, 1897.

marked in the same way, but one is remote and the other closer at hand. To detect this the Zebra must be regarded from a moderate distance and not at so great a distance that the stripes blend into a uniform grey, as is said to be the case*.

Text-fig. 50.

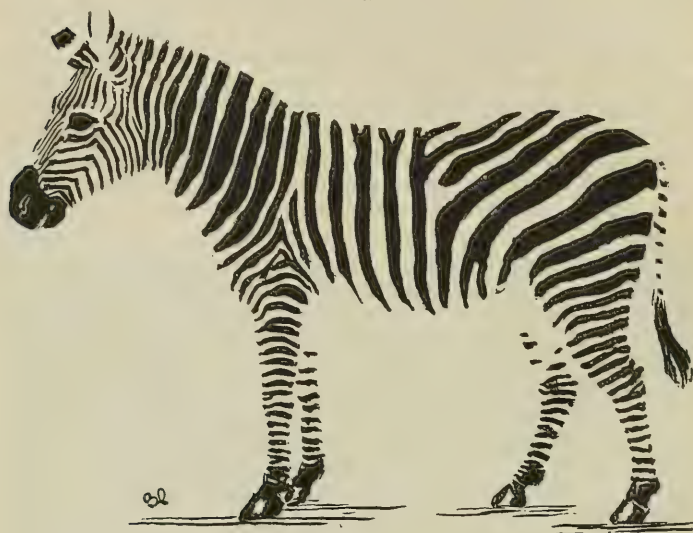


Diagram of one of the northern races of *Equus quagga*, to show how variation in the direction and the width of the stripes contributes to the procryptic effect of the pattern.

"Other striped species of the genus *Equus* exhibit similar phenomena, but none shows the division down the middle of the side which is so marked a characteristic of the existing forms of *E. quagga*. In *E. zebra* and *E. foai* the change of direction does not take place until the hind-quarters are reached; but on this area in *E. zebra* there is not only a difference in direction of the stripes, but an extraordinary difference in their size, so that the greatest possible contrast is secured. Finally, of all the Zebras *E. grevyi* is perhaps the most uniformly striped, but the small striped head is severed from the small striped shoulder by the neck, the stripes of which, at least in its posterior half, are usually of comparatively enormous width. But in the foal of this species what may be described as an attempt at the optical division of the body into two halves is made. This is effected not by an alteration in the direction of the stripes, but by an alteration in their

* There is, in my opinion, very little doubt that the sharp contrast in colour between the black anterior and white posterior parts of the body of the Malayan Tapir (*Tapirus indicus*) has a procryptic significance similar to that achieved by the alteration in the direction of the stripes seen in existing forms of Quaggas.

colour, the stripes on the cheek, neck, and shoulders being black and sharply contrasted with those on the posterior part of the body and quarters, which are rusty brown. This at least was the case in the only foal of this species that I have seen, namely, one born in the Gardens. Another interesting feature about this little animal was the presence of an erect, thick mane, mostly rusty brown in colour, which was continuous with the neck-mane on the withers and extended backwards down the spinal stripe, over the tail to the tail-tuft. And if, as appears highly probable, Prof. Ewart is correct in thinking Grévy's Zebra the most primitive type in the matter of pattern, it may be that this transitory spinal mane in the foal of that species is evidence that the ancestor of all Zebras, and inferentially of all Equidae, since *E. grévyi* is, in my opinion, proved by his braying voice to be nearly akin to the African Wild Ass, possessed a mane running from the crown of the head to the tip of the tail."

The following papers were read:—

1. A Review of the Species of the Lepidopterous Genus *Lycænopsis* Feld. (*Cyaniris* auct. nec Dalm.) on examination of the Male Ancillary Appendages. By T. ALGERNON CHAPMAN, M.D., F.Z.S.

[Received March 17, 1909.]

(Text-figures 51-122.)

This genus has been generally known as *Cyaniris* Dalman, since Scudder so defined it in 1872. Prout, however, calls attention to the fact that Dalman himself gave *semiargus* (*argianus*) as the type, a circumstance that Scudder in some way overlooked.

Felder, in 1865, gave *Lycænopsis* as a generic name to *haraldus* (*ananga*), and there is now a fair consensus of opinion, which the observations reported in this communication fully support, that *haraldus* is a species of *Cyaniris* (Scudder). Mr. Prout tells me that notwithstanding Felder gave the name *Lycænopsis* to express his opinion that *haraldus* was *not* congeneric with anything else, the rules at present accepted make *Lycænopsis* the generic name of *Cyaniris* (Scudder). Mr. Tutt, in 1906, unaware of the claims of *Lycænopsis* to this position, provided the name *Celastrina* with *argiolus* as type. Should some one find reason to divide *Lycænopsis* into several genera, *Celastrina* would become the name of that containing *argiolus*. I do not myself see, at present, any reason for such subdivision of *Lycænopsis*, and could not frame divisions, without using as generic characters features that seem to me to have only specific value. It remains to remark that, as *Cyaniris* has had a start of only 30 years, it hardly claims place under the new agitation for advocating usage *v.*

priority. Such new practice, moreover, would only be binding after each case was determined by a Committee, appointed by the Zoological Societies of the world. Short of this it would only prolong the confusion due to a struggle ultimately to be decided in favour of priority.

I was led to examine this group by Mr. Tutt desiring me to investigate *L. argiolus*. I found this could not be done without dealing with a number of other, chiefly Indian, species, and these again required, or at least suggested, a still wider view, so that I finally took up the whole genus, so far as I could obtain access to material. No doubt, my view is still narrower than it ought to be, because I have not gone fully into the most nearly allied genera. I have, in fact, made observations of some of these, but it was obvious that I must draw the line somewhere and take the risk of such errors as ignorance of what was beyond it might lead me into.

Another serious limitation was found in the fact that specimens of some species could not be obtained for examination, and this unfortunately was apt to affect most especially type and other more valuable specimens. Still, I have examined a great deal of material, but there are six species of which I know little, of one of these only the ♀ is known, and several of the others seem to be probably synonyms.

I have examined a good many species in the British Museum Collection at South Kensington, and am also under great obligation for the privilege of examining many specimens from the Rothschild Collection at Tring. Mr. H. H. Druce has afforded me assistance with specimens and aid in determining species. Mr. Bethune-Baker has kindly allowed me to examine specimens including several types from his collection. I have also had specimens from the Godman Collection, from that of the Oxford University Museum, and elsewhere. The late Col. Bingham also most kindly assisted me with specimens and afforded me the valuable aid of the researches he had made in writing the volumes on the "Butterflies" in the 'Fauna of British India.'

I have found considerable difficulty in making sure that the specimens I examined were correctly named, and in the absence of access to types of well-known species, the authority of the works of Moore, de Nicéville, and Bingham, for the Indian species, was generally found to be adequate.

My observations of the genus lead me to the conclusion that the upper surface is often more misleading than otherwise as to what species some particular specimen belongs to. As to the under surface, I believe the pattern of the spotting is to be thoroughly depended on for specific characters. But then it unfortunately happens that the pattern is not unfrequently quite obscured by seasonal, geographical, and other variations, the spots being much enlarged, or some of them reduced almost or quite to obsolescence. They may be very dark or very pale, and so on. It has happened to me several times that I saw no identity

between the spots of two specimens of the same species until an examination of the appendages led me to believe they might be the same species, and with this indication an identity of the arrangement of the spots in both could easily be accepted.

Considering these difficulties, it is not to be wondered at that some confusion has, hitherto, existed as to certain species. The wonder is that the amount of accuracy, that actually obtains, has been achieved. I would, however, sincerely beg no one to name any more "species" until he has fairly located them as new or otherwise, by examining the appendages, which give an uncertain answer in very few cases.

What appealed to me as perhaps the most interesting circumstance I have unearthed, is the remarkable (apparently mimetic) variation that occurs in *L. argiolus*. Possibly the hope of meeting with similar cases urged me to continue the researches. Though other species present considerable variations of the same character, their number and range is far short of that of *argiolus*. It remains, however, very possible that many more similar cases are still to be discovered when larger series of specimens from the different Malayan islands are available for full discussion.

I have not found any account of the ancillary appendages of this group, but I am not a successful searcher of literature; still, I believe no such account exists. Some observations have, however, been made, as I find that Doherty (J. A. S. B. 1886, p. 134) refers to the value of the "Prehensores" for distinguishing the species of the group. I cannot discover, however, that he afterwards published any details.

Though I have examined the ancillary appendages of various Lepidoptera of many different families, I am much impressed with the fact that my knowledge is really very superficial and fragmentary. The result is, that in defining the generic characters of these organs in *Lycænopsis*, I do not experience very much confidence.

Throughout the Lycænidæ it is hardly too sweeping a statement, so far as my observations go, to define the dorsal armature as consisting of two lateral halves with more or less of a hiatus between them, each lateral half carrying near its base a paramere or appendage, articulated to it so as to be freely movable and more or less curved, bent, or twisted. In a few genera the two lateral halves coalesce in the middle line. In *Lycænopsis* we have a remarkable specialization of these dorsal processes, a specialization by way of simplification or loss of parts. The movable paramere or hook is quite wanting.

This specialization is so remarkable as at least to justify the inclusion in the Lycænopsids of all genera that show this specialization, of which at present I have only recognized *Castalius*, *Megisba*, and *Neopithecops*. Of those genera apparently near that possess these hooks, such as *Pithecops*, *Niphanda*, &c., the only one that I incline to regard as Celastrinid is *Zizera*,

[type *maha*, not *alsus* (*minimus*); *alsus* is an Everid and was stated to be the type of *Zizera* by Moore under some misapprehension. It does not possess the characters by which he defines the genus, whilst *maha* (and other Indian species) does].

Two species placed in *Lycænopsis*, viz. *vardhana* and *musina* (*lugra*), possess these hooks, and probably require each a separate genus, but I shall satisfy myself for the present by placing them in the genus *Notarthrinus*, instituted for an apparent *Lycænopsis*, possessing this character. *catreus*, rather an aberrant form, would be just within *Lycænopsis*. Before inventing genera for these, it would be well to know something of their life-histories.

This tolerably uniform structure of the dorsal armature throughout the true Lycænopsids reinforces the remark I made a number of years ago, in discussing the morphology of these structures in the genus *Erebia*. I then observed that the dorsal appendages were fairly constant throughout a genus, whilst the clasps varied very much, and yet very similar variations in the clasps could be found in allied genera clearly marked off by the dorsal structures.

These lateral hooks of the dorsal armature must be, from their constancy throughout the Lycænids, of some essential use, which we must suppose was not imperative in the Lycænopsids. Nevertheless, in *Lycænopsis* we find that some species apparently regretted the loss, but under the law that lost parts cannot be regained, could only meet their desires by developing a more or less hard and sharp point as part of the lateral dorsal process, most highly developed in *L. limbata* (19).

In the few notes I may make on the appendages of each species, I certainly do not attempt any full description, trusting, so far as that goes, to the photographic reproductions. In such remarks as I may hazard, my objects are rather to call attention to points that mark their agreements or differences with other species, as hints to their affinities, and to points not clearly brought out by the photographs.

In preparing the specimens, I found that to secure their being satisfactorily photographed and easily compared under similar conditions, it was necessary to make them quite flat and all in the same manner: this is true of preparations of ancillary appendages of most groups, but the question varies in each group as to how such flatness may best be attained. In some groups it is well nigh impossible. In the Lycænopses I find it fairly satisfactory to divide the basal chitinous ring in the medio-dorsal line and spread it out, so that the extreme ends of the preparation are the separated dorsal portions of the ring. The photographs appended are nearly all from such specimens. They are mostly magnified 45 diameters, more or less reduced on reproduction, but there are a few exceptions. The photographs are by Mr. F. Noad Clark, whose technique leaves nothing to be desired, except specimens mounted in a more finished and less amateur manner to operate on.

In one or two instances specimens are mounted so as to show the dorsal armature in more natural relations, as one of *dilecta* (23), of *selma* (29 a).

It is a matter of congratulation from my point of view, that the three species that are especially widely distributed and of most protean aspect, viz., *argiolus*, *puspa*, and *limbata*, have ancillary appendages that are absolutely distinctive and widely marked off in each case from those of any other species and are also given to very little variation, geographical or other. It is different with the *dilecta* group of species which do not differ widely from each other, and amongst which I think it possible there are still one or two undetected species, but my information is too imperfect to enable me to deal adequately with this section.

I think the latest complete list of *Lycænopsids* is that by Dr. A. G. Butler in the 'Annals and Magazine of Natural History' for 1900, ser. 7, vol. v. p. 441. It is curious that though de Nicéville (1890) characterises the genus correctly, Dr. Butler should define it by one character only, and that one, one that it does not possess—the costal vein of the primaries is *not* united by a cross-vein to the first subcostal branch. This cross-vein is rare in *Lycænines*, and it is absent in all the genera having *Lycænopsis* affinities. It is present in the *Everids* and some few other genera.

Dr. Butler enumerates 57 *Cyanirids* and 3 doubtful species. To these 60 species there are in addition several further species described since and one or two he had overlooked, making 66 in all. Of these two are *Everids* (*Bothrinia*), three belong to *Notarthrinus*, and perhaps are hardly *Celastrinid*, one (*pryeri*) requires a new genus (*Artopoetes*), leaving 60 to *Lycænopsis*. Of these 60 forms I have not examined 7 or 8, but believe several of them would be sunk under other names were that done. The remaining 52 appear to belong to 30 distinct species, 22 being usually varietal forms rather than synonyms, but in either case included in the 30 "good" species.

I have added photographs of examples of the three genera that appear to me to be undoubted *Lycænopsids*—namely, 45, *Megisha malaya*, 46, *Neopitheops zalmora*, and 47, *Castalius ethion*; it will be observed that in each of these the dorsal armature is without an accessory hook.

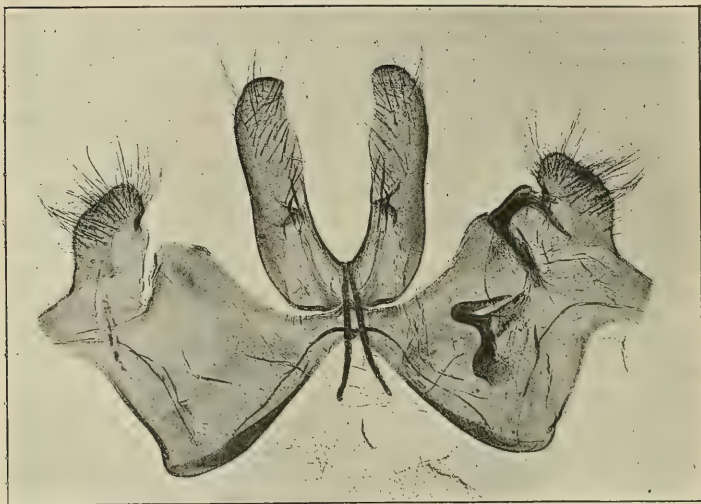
I may begin with those species that I separate from *Lycænopsis* under the genus *Notarthrinus*, of which the definition is apparently *Lycænopsis*, but with hooks to the dorsal processes of the appendages. Of these there are three species, *vardhana*, *binghami*, and *musina*, sufficiently different from each other to be doubtfully accommodated together in the same genus. In the boldness of the teeth of the clasps, *musina* seems related to the group of *Lycænopsis* containing *nedda*, *shelfordi*, *corythus*, &c. If this be so, this group would probably be the earliest or lowest species of the genus.

NOTARTHINUS.

1. *vardhana* Moore, P. Z. S. 1874, p. 572, pl. lxvi. fig. 5.

The dorsal armature possesses the accessory articulated hooks, so that it is not a true *Lycænoopsis*. I place it provisionally in *Notarthrinus*.

Text-fig. 51.*



vardhana. $\times 33$.

2. *binghami* Chpm. P. Z. S. 1908, p. 676, pl. xxxviii. fig. 2.

Very like *Bothrinia chennellii* and *Lycænoopsis limbata* var. *jynteana*, and until recently not distinguished from them. The appendages are very different.

(Appendages illustrated l. c.)

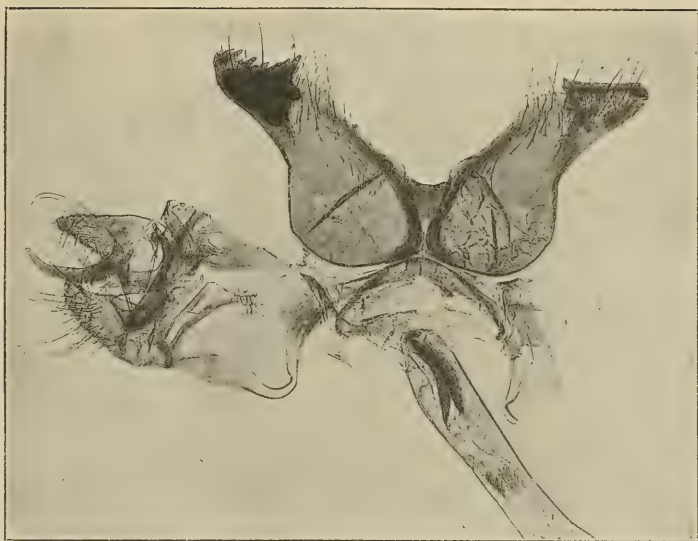
3. *musina* de Nicév. J. Bomb. N. H. S. ix. p. 275, pl. O. fig. 19.

¶ Specimens of this species in the British Museum collection are also labelled *corythus*—leading me at first into some errors,—specimens of *corythus*, however, exist there unnamed.

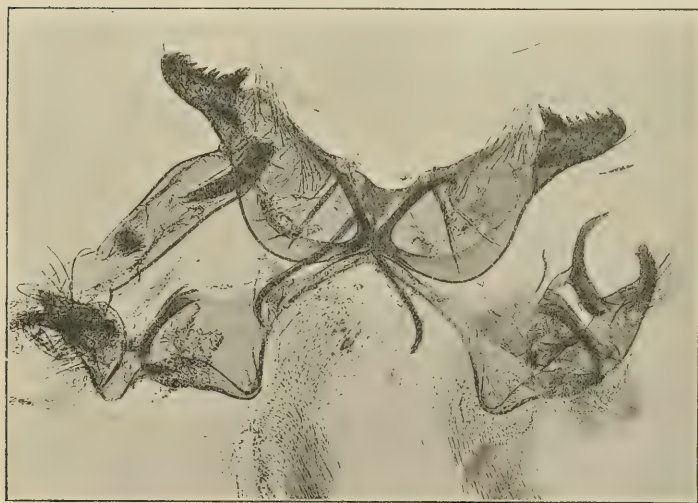
† This species is on the margin of, or rather outside, the genus *Lycænoopsis*. It possesses articulated hooks to the dorsal processes, and the terminal armature is differently arranged to that of any other species. In its large and bold spines it resembles *corythus*, *cinctata*, and *transpecta*, and some others, most of which

* [Text-figures 51–122 represent in each case the male ancillary appendages of the species indicated in the legend.]

Text-fig. 52.

*musina* (labelled *corythus*, B.M.). $\times 33$.

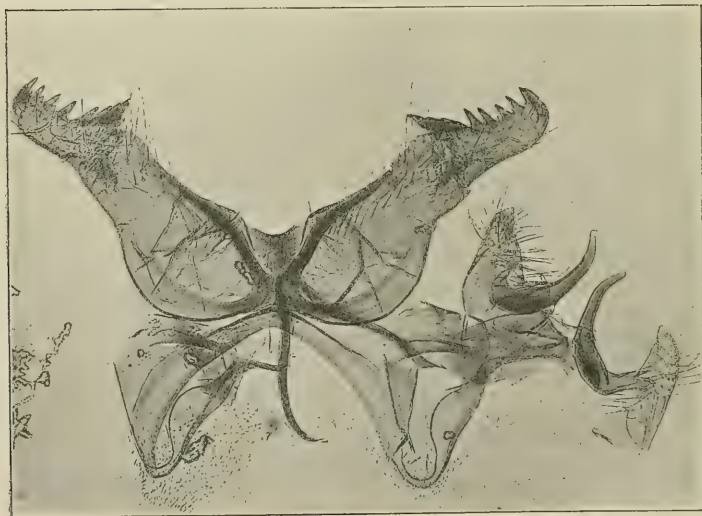
Text-fig. 53.

*musina* (B.M.). $\times 33$.

Text-fig. 54.

*musina (lambi, Oxford Coll.).* $\times 41$.

Text-fig. 55.

*musina (lugra, Druce Coll.).* $\times 41$.

have also a soft (not jointed) small appendage on the ventral side of the dorsal process, that probably represents the obsolete hook.

If this be so, *musina* would be an ancestral form, hardly yet a *Lycænopsis*, and the others referred to would be the earliest true *Lycænopsids*.

3 *a. lugra* H. H. Druce, P. Z. S. 1895, p. 573, pl. xxxii. fig. 5, has identical appendages and differs from *musina* most in the upper surface-colouring. It is to be regarded as a geographical race of *musina*.

Text-fig. 56.



musina (*lugra*, Tring Coll.). × 41.

LYCÆNOPSIS.

In classifying the appendages, there are no grounds apparently for supposing one can easily at the same time classify the species.

One is inclined to begin with *puspa* as almost the only species that can be said to have a hard (spinous) and soft (hair-clothed) process to the clasps, because this seems to be not only a primitive *Lycænine* but even a primitive lepidopterous character, following with *argiolus* as possessing vestiges of the soft process. In other species the soft process is merely constructively present. After these would come such species as *oreas*, *phillippina*, &c., in which the spinous process bends down, and in *corythus*, *nedda*, &c. displays the teeth as marked spines.

In another direction the hard or spinous process dwindles to small dimensions, retaining many teeth, as in *dilecta*, *lanka*, &c.; culminating in species in which it is very small, as in *placidula*, *melena*, &c.; and finally wanting, as in *plauta*. There are other species that seem each to be a law to itself, such as *albocarulea* and *transpecta*.

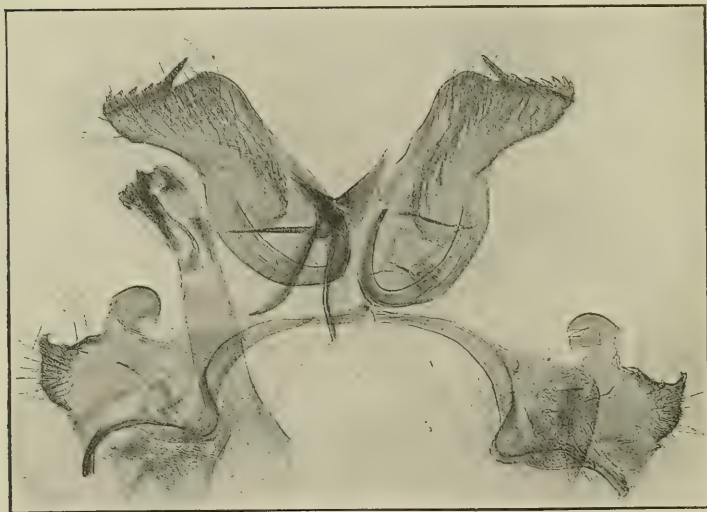
A group might be made of those that have, not a hook, but a spine to the dorsal process; it would not, in regard to the clasps, be a natural group. It appears to include *limbata*, *marginata*, *phillippina*, *nedda*, *acesina*, *camenae*, *argiolus*.

I propose to place first those with several large teeth to the spinous process.

4. *corythus* de Nicév. J. B. N. H. S. ix. p. 273, pl. O. figs. 16, 17.—Sumatra.

The appendages belong to the group with long teeth in the spinous process of the clasps—*nedda*, *acesina*, *shelfordi*, *musina*. The dorsal processes have a definite spine and a button-like ventral accessory.

Text-fig. 57.



corythus (Sumatra, Druce Coll.). $\times 32$.

In the British Museum specimens of *musina* are placed under this name, which led in my earlier examinations to my believing *corythus* and *musina* to be the same species (Proc. Zool. Soc. 1908, p. 677). They are abundantly different in all respects.

5. *shelfordi* de Nicév. J. B. N. H. S. xiv. p. 245, pl. FF. fig. 7.—
Borneo.

The dorsal process is without a spine, the ventral accessory is flat and rounded but well chitinated; the clasp is short and the end broad, with very strong and long spines, the secondary ones being strongly developed. One might describe it as a strong-spined form like *nedda* trying to shorten itself down to the form of *placidula*.

Text-fig. 58.



shelfordi (Druce Coll.). $\times 40$.

6. *nedda* Grose-Smith, Nov. Zool. i. p. 572.

6 a. *cinctata* Grose-Smith, Nov. Zool. ii. p. 506.

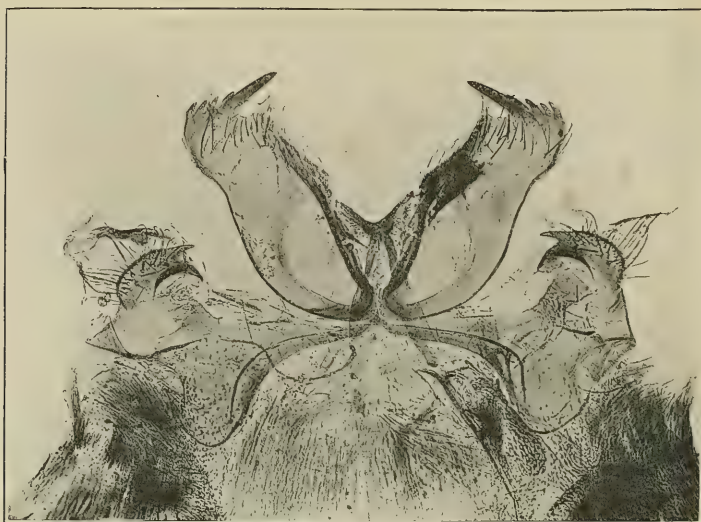
6 b. *phuste* H. H. Druce.

nedda and *cinctata* appear to agree in imaginal characters except as regards the width of the dark border. Whether they are geographical or seasonal varieties I do not know. I have, under *phuste*, given my reasons for considering this form probably an aberration of *nedda*.

A specimen labelled *aga* in the Godman Collection (now B.M.) and one labelled *ananga* in the Brit. Mus. Collection belong to this species.

The dorsal processes have a short sharp ventral spine; the clasps are short and broad and have the outer face of the spinous process facing distal, with very large bold teeth, 4 or 5, culminating in a very strong terminal one; the notch beneath is marked.

Text-fig. 59.

*nedda.* $\times 41$.

Text-fig. 60.

*nedda (cinctata).* $\times 43$.

Text-fig. 61.

*nedda* (*aga*, Godman Coll.). $\times 44$.

Text-fig. 62.

*nedda* (labelled *ananga*, B.M.). $\times 44$.

- 7 (6 b). *phuste* H. H. Druce, P. Z. S. 1895, p. 573, pl. xxxiv. fig. 17.

I have seen the type specimen, which is I believe unique. Not having examined the appendages I can make no positive assertion, but I see no difference between *phuste* and *cinctata* except the absence on the under side of all spots except the marginal ones. This is a form of aberration one expects to meet with occasionally in most *Lycænines*. Ordinary *cinctata* occurs in Dili, whence this specimen comes.

8. *cara* de Nicév. J. B. N. H. S. xii. p. 143, pl. Z. figs. 19 & 20.

I have not had an opportunity of examining this species. It seems related to *acesina*.

9. *acesina* Bethune-Baker, Ann. Mag. N. H. ser. 7, xvii. p. 103 ; P. Z. S. 1908, p. 117, pl. viii. fig. 10.

The appendages here are very distinct. It is not far from *nedda* in general structure, but it is even bolder and more spinous. The ventral spine of the dorsal process is very strong and sharp. The spinous process of the clasp is separated off as a head with a distinct neck, the base carrying the inferior spines being much enlarged (as compared, say, with *nedda*), and projecting some distance beyond the large bold terminal spine. In *musina* this development is carried further.

I have not seen *L. cara*, but the figures suggest it is closely allied to *acesina*, possibly the same species.

10. *transpecta* Moore, P. Z. S. 1879, p. 139.

The appendages differ much from those of any other species of *Lycænopsis*. The dorsal process differs from that typical of the genus in having a soft ventral process. The clasps have a wide unarmed extremity, but marked teeth exist along the ventral margin. *corythus* is the nearest form ; *musina* has some similar features (see *musina*).

The soft ventral process of the dorsal armature is probably a vestigial remnant of the base of the typical hook, and may mark the species possessing it (*corythus*, *catreus*, &c.) as earlier forms.

11. *phillippina* Semper, Reise Philipp. II. v. p. 168.

A specimen in the Godman Collection (now in Brit. Mus.) is almost certainly correctly named. The appendages are very distinct from those of any other species. The dorsal process has a sharp ventral point. The clasps are short, very broad and stout, and end by continuous tapering, but with a sharp curve, in a strong spinous process with teeth along the distal edge and ending in a large robust point. It is most nearly allied to *oreas*.

Text-fig. 63.

*acesina*. $\times 42$.

Text-fig. 64.

*transpecta*. $\times 12$.

Text-fig. 65.



phillippina (Godman Coll.). $\times 42$.

12. *oreas* Leech, Butt. Chin. p. 321, pl. xxxi. figs. 12–15.

This is a well-marked species. The clasp somewhat resembles that of *phillippina*, but is perhaps nearer to *puspa* or *nedda* in so far as that the inner angle (soft process) instead of sloping away is fairly produced; the terminal spine is large and sharp, those below it are mere notches—smaller and smaller as they recede, to the number of six or eight. The dorsal process has a ventral spine.

There is a specimen in the British Museum labelled *singalensis*, Khasia Hills. This may be one of the specimens mentioned (from the *Nilgiri* Hills) by de Nicéville, Butt. Ind. iii. p. 108, and adds *oreas* to the Indian fauna unless there be some error in labelling, which I see no reason to suspect.

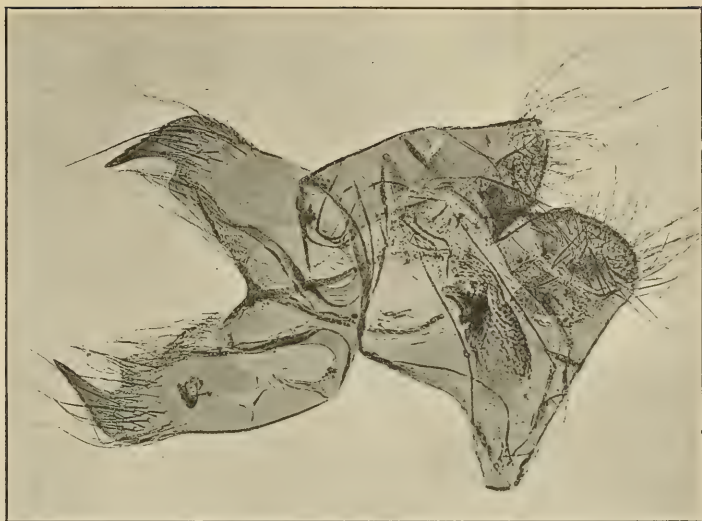
13. *haraldus* Fabr.

The clasps are broad and short, like *phillippina*, *oreas* and *ripte*, but are larger, and the spine is larger than in *ripte*, having large and bold teeth, and as long as the width of the clasp. The dorsal process has a small accessory on its ventral side.

14. *ripte* H. H. Druce, P. Z. S. 1895, p. 574, pl. xxxii. fig. 11.

In form of clasp this species is very near to *placidula*, excepting that the spinous process is well developed, not only extending

Text-fig. 66.

*oreas* (China). $\times 42$.

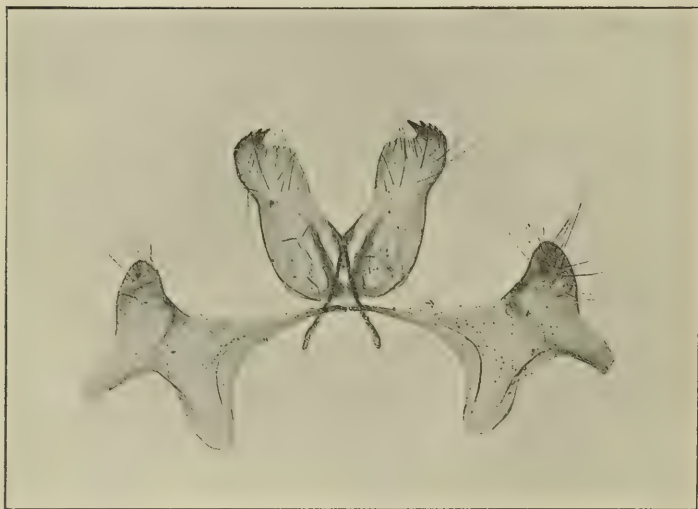
Text-fig. 67.

*oreas* (labelled *singalensis*, Khasia Hills, B.M.). $\times 32$.

Text-fig. 68.

*haraldus*. $\times 44$.

Text-fig. 69.

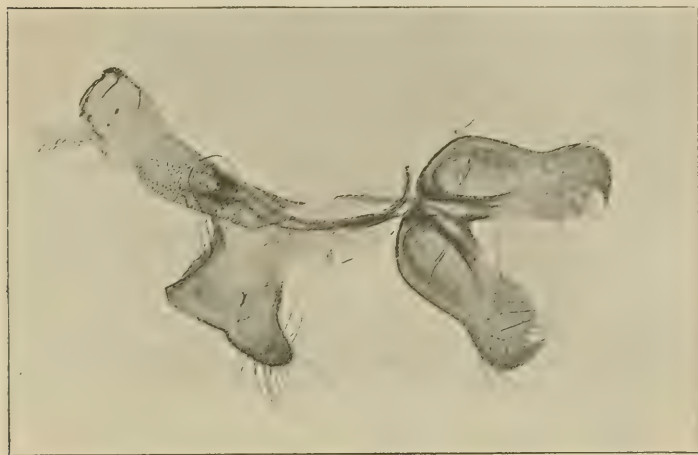
*ripte* (Godman Coll.). $\times 41$.

two-thirds of the width of the clasp across its end, but having a deep notch below it and having five large marginal teeth, graduated larger to the terminal one, which is strong and bold.

haraldus is very near it, but is larger and more robust.

There is no dorsal accessory process.

Text-fig. 70.



ripte (Oxford Coll.). $\times 37$.

15. *puspa* Horsf. Cat. Lep. E. I. Co. p. 67. n. 3 (1828).

This seems to be the most abundant and most widely distributed species after *argiolus*. Like *argiolus* it has received in several varieties distinct names, in the belief that they were distinct species. Its distribution appears to be over practically the whole Indo-Malayan region, and we know that in many of the islands the species is found, often with a very definite varietal facies, and it is probable that nearly every island in the region possesses a race of *puspa*.

puspa may always be recognised by the spots of the upper wing (beneath) having those between veins 2 and 3 and 4 and 5 oblique, with the intermediate ones fairly straight and nearly in the line joining the centres of the oblique ones, and that between 4 and 5 on the hind wing being similarly longitudinal rather than transverse.

The appendages are nearer to those of *argiolus* than those of any other species. The very similar spiculate spine, instead of having four or five teeth, has a very large number of very minute ones. The body of the clasp is also very much longer proportionally.

The following recognised(?) species are apparently varieties of *puspa* :—

timorensis Butl. A. M. N. H. v. 1900, p. 443. Timor.
dammæ Heron, A. M. N. H. xiv. 1894, p. 104. Damma I.
splendens Butl. A. M. N. H. v. 1900, p. 444. Perak.
kuhni Rüber, Isis, i. p. 60. Ké.
imperatrix Butl. A. M. N. H. v. 1900, p. 444. Siam.
cajaya Felder, Reise Novara, Lep. ii. p. 278. Luzon.
cyanescens de Nicéville, Butt. Ind. iii. p. 103. Nicobar.
puspinus Kheil, Rhop. Ins. Nias, p. 30. Nias.
lambi Distant, A. M. N. H. ser. 5, xix. p. 266.

Of these, *cyanescens* has a coloration that makes one doubtful of its identity with *puspa* until an examination of the appendages shows them to be truly the same species.

Amongst other forms (and localities), some of which may have been named though I have not discovered it, and for each of which I would suggest, should a varietal name be desired, a varietal name indicating the habitat, may be mentioned :—

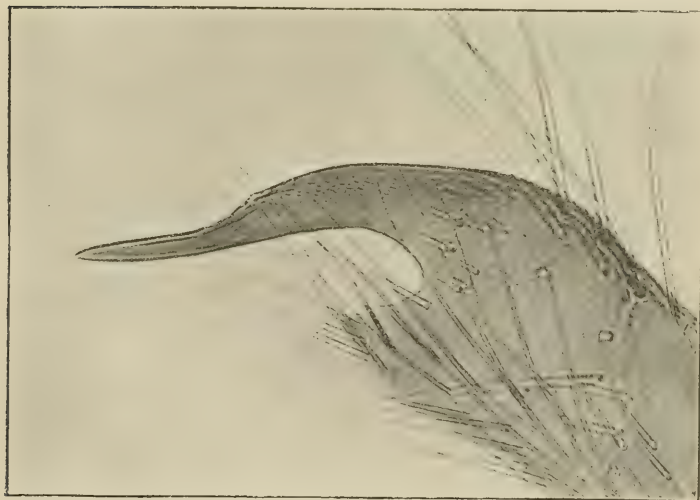
1. A large form (34 mm.) with large white patches on all four wings, and very white under side on which the usual spots stand out very black and crisp. From Sumbawa. Tring Coll.
2. A form almost identical with *cyanescens*, but with the special tint of that form less pronounced; under side with a grey tone. Ravau. Tring Coll.
3. A moderate-sized form (30 mm.) with white patches indicated on all wings; under side a little clouded. From Celebes. Tring Coll.
4. Moderate size (33 mm.), broad border, no white patches or discal streak; under side grey-clouded. Battak, N.E. Sumatra. Tring Coll.
5. (34 mm.) Narrow border, white patches hardly indicated; under side clouded grey. Bungurun, Natuna Island. Tring Coll.
6. A very narrow bordered form (35 mm.), white patches hardly indicated, slightly clouded beneath. Palawan. Tring Coll.
7. A fairly ordinary form with white patches. From Sawela, Lombok. Tring Coll.
8. A very dark blue form without white patches. Sula Resi. Tring Coll.

Miskin mentions that it occurs in Australia, but without quoting definite data. G. A. Waterhouse is doubtful whether it does so.

Text-fig. 71.

*puspa.* $\times 44$.

Text-fig. 72.

*puspa*, end of clasp. $\times 162$.

Text-fig. 73.

*puspa (imperatrix?*, Luzon, Tring Coll.). $\times 45$.

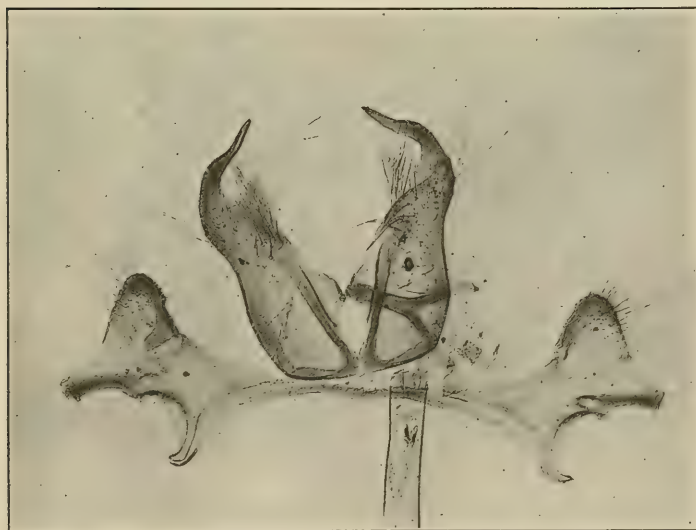
Text-fig. 74.

*puspa (cajaya)*. $\times 32$.

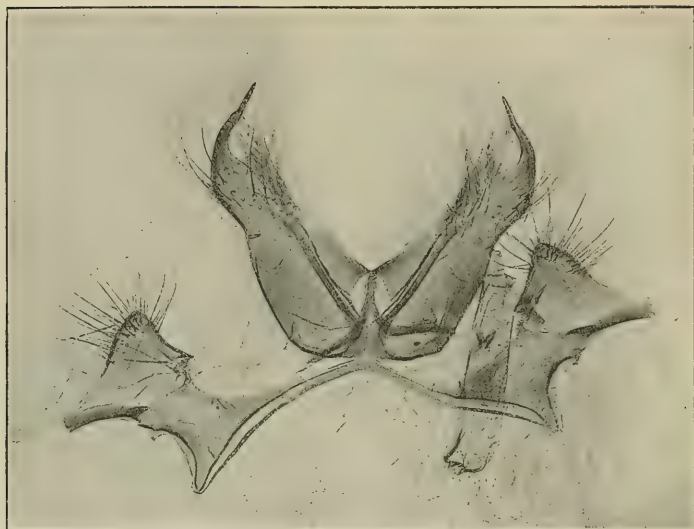
Text-fig. 75.

*pupa (lambi, Godman Coll.).* × 43.

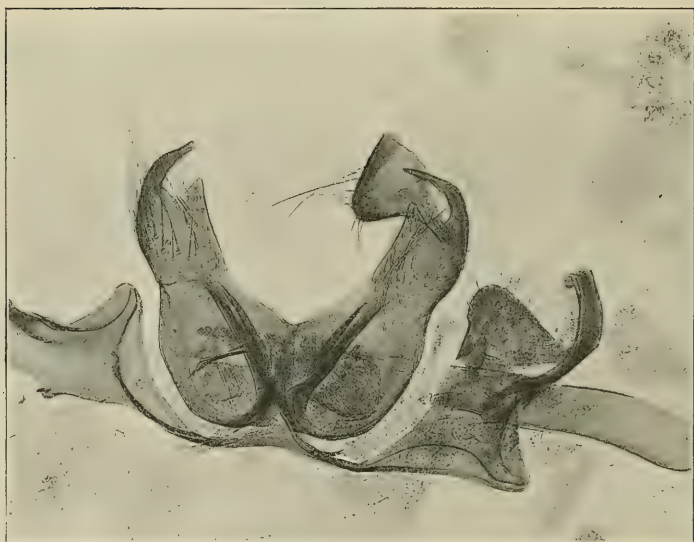
Text-fig. 76.

*pupa (duponchellii, Godman Coll.).* × 45.

Text-fig. 77.

*puspa* (labelled *dammæ*, Shevoray, Tring Coll.). $\times 45$.

Text-fig. 78.

*puspa* (Sumbawa, Tring Coll.). $\times 44$.

16. *argiolus* Linn.

A good deal of what I have done in investigating this species will be found in Tutt's account of it (Brit. Lep. vol. ix. p. 387 *et seq.*), and in Proc. Ent. Soc. Lond. 1908, p. lxxxi.

The number of named varieties, races, and aberrations is very great. I have examined a very large number of specimens, and the ancillary appendages are all identical and quite unlike those of any other species of *Lycænopsis*, *puspa* being perhaps the nearest. The amount of variation in the appendages is apparently confined to the greater or less prominence of the four or five teeth on the spine of the clasp. They are never entirely obsolete; and are perhaps as pronounced in British specimens as in those of any other race. The soft process of the clasp varies a little in its prominence, though this may depend sometimes on slight variations of procedure in mounting the specimens.

Text-fig. 79.

*argiolus* (English). $\times 37$.

I will not deal with varietal names, beyond one or two in addition to those that I find in Dr. Butler's list.

Dr. Butler confines the name *argiolus* to the European form, to the American form he gives the name *ladon* Cramer; Cramer's figure looks like a *Lycænopsis*, and like an *argiolus*. The assigned locality is obviously erroneous, but whether the specimen actually came from Europe, Asia, or America, is quite a matter of doubt. *pseudargiolus* seems therefore the name for the American form.

There seems to be no other American *Lycænopsis*, but the species is found over the whole of North America, from Central America to Canada, with a profusion of named and unnamed races and aberrations.

The Asiatic forms mentioned by Dr. Butler are :—

levettii Butler. Corea.
huegelii Moore. Himalayas.
ladonides de l'Orza. Japan.
cælestina Kollar. Western India.
victoria Swinhoe. Shillong.

The last species astonished me a good deal when I first found it to be a race of *argiolus*, but its markings, &c. are found to conform to those of *argiolus*.

One of the most interesting features of the Indian *Lycænopsids* is the parallel variation of certain species, and probably of others the variability of which has not so directly come under my notice.

The first point to attract my attention was the similar forms found in *L. argiolus* and *L. limbata*.

We have *L. argiolus* vars. *huegelii* and *cælestina* paralleled by *L. limbata* and its var. *placida*. This would not strike one as remarkable were it not for the further close likeness between *argiolus* var. *sikkima*, and *limbata* var. *jynteana*.

These two forms were distinguished by Moore and separately described, but he afterwards was obviously unable to name them with certainty, and there is a specimen of *sikkima* in the Brit. Mus. Collection named by him *jynteana*.

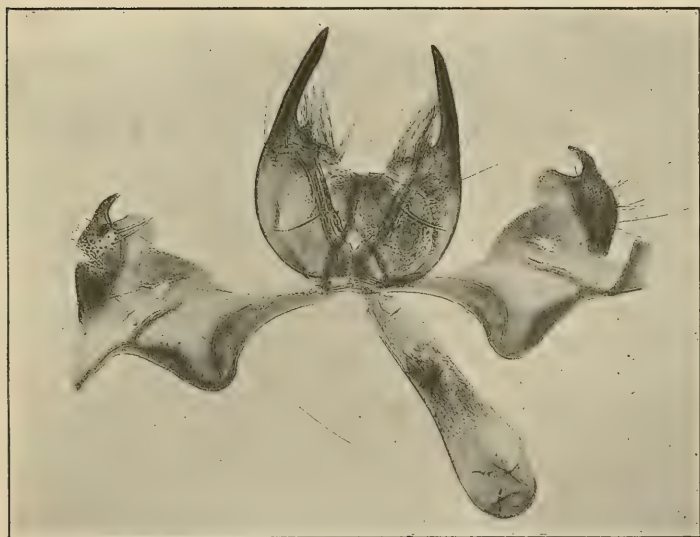
De Nicéville, Butt. of India, vol. iii. p. 105, treated the distinction between these two species with more than scepticism, and Bingham sinks *sikkima* as a synonym of *jynteana*. Both forms seem to vary in the breadth of the dark border and in the presence or absence of a discal line, but *sikkima* inclines to the broadest border and is less rarely without the line. Apart from the ancillary appendages, which show *sikkima* to be a form of *argiolus* and *jynteana* to be a race of *limbata*, the structures being exceedingly different, the two forms may be separated by the line of spots under the fore wing, the third spot (second of those in a row, the first being moved inwards) being slightly oblique in *jynteana* (as it is in the co-specific forms *limbata* and *placida*), whilst it is like the others in *sikkima* (as it is in *argiolus*, though there are some races in which this varies).

There are two further forms of *argiolus* that I hardly like to give separate names to, because they are really very close to *sikkima*, if not identical: one of these flies with *L. puspa*. Of this I have four rather poor specimens received in papers from Col. Bingham, along with a number of *puspa* collected by Col. E. R. Johnson in Assam: submitted to Col. Bingham, he thought they might be *jynteana*, *puspa*, *albocerulea*, or *chennellii*. They were, as we have seen, *jynteana* in almost the same sense that *sikkima* is *jynteana*. It is really very close to *sikkima*, but

Text-fig. 80.

*argiolus (pseudargiolus).* $\times 42$.

Text-fig. 81.

*argiolus (labelled limbata, Godman Coll.).* $\times 40$.

has a rather wider border, and the discal streak has a pale patch in the blue like *puspa*. If it must have a name, it might be *argiolus* var. *puspargiolus*.

The other form equally close to *sikkima* flies with *Bothrinia chennellii*, so far as I can judge, and has been sent to me as that species. It has a still broader border, and would certainly not suggest itself as a form of *argiolus* until the ancillary appendages had been examined. This form might be called *bothrinoides*. The first spot beneath the upper wing being thrown inwards (as in *argiolus*) easily distinguishes it from *chennellii*.

There is a further variety of *argiolus* that I have called *albo-cæruleoides*; it is rather further from *sikkima* than the two forms (*puspargiolus* and *bothrinoides*) just noticed, but nearest to *puspargiolus* in having a whitish patch in the blue of both wings; the black border is, however, less extensive. There is a specimen (or more) of this in the B.M. Collection labelled *albo-cæruleus*, but it really is nearer to *marginata*; and I have specimens of unknown origin of *marginata* and *albo-cæruleoides*, the pinning and setting of which suggest that they were taken together. One can hardly avoid believing that there are probably races of *argiolus* not yet observed that approach other species of *Lycenopsis* in appearance.

There is a further form, in which the discal line is evident and the black border narrower, but with distinct traces of lunules on the margin of the hind wing and very pale in the blue colour. There are specimens in the British Museum from Burmah, and I have seen others labelled *jynteana*, without locality; but for its larger size, this is not very unlike *victoria*, especially in the fading of the blue into a greyish tone, in which it has not gone far, but still has moved in that direction.

There is still *Lycenopsis victoria* Sev., which I found to my astonishment to be also a race of *argiolus*. The conclusion can hardly be resisted that it also has adopted a resemblance to some other Lycenid, but I am not prepared to suggest what this may be.

There are sundry other *Lycenopsids* that suggest that they have local races to accord with other species, but I know too little of these to be able to say more than that such conditions seem probable. In most of these cases, however, the explanation of simple geographical variation is at least quite as probable, as in the case of *L. cyanescens*, the very different looking form that *puspa* assumes in the Nicobars.

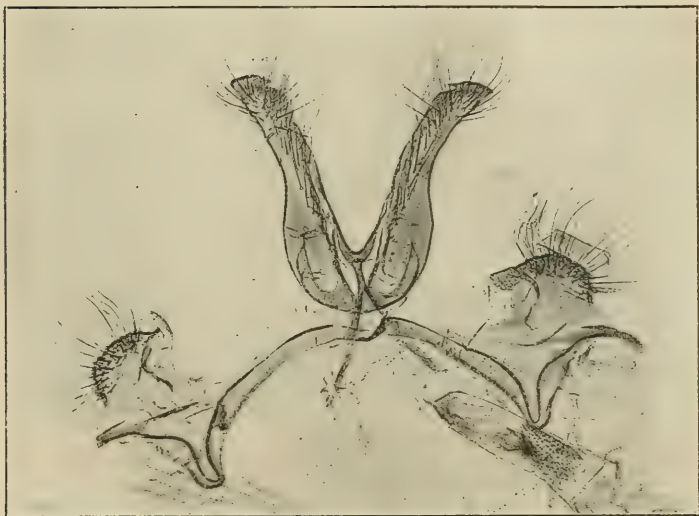
17. *albidisca* Moore, P. Z. S. 1883, p. 524, pl. xlviii. fig. 7.

The appendages show this species to be related to *marginata* as closely as the general appearance of the imagines might lead one to suspect.

The spines of the dorsal processes are less pronounced, the accessory processes on their ventral side are at least equally distinct; the shoulder of the spinous process of the clasp, so usually

rounded, is here, as in *marginata*, sharply angular; the process itself is smaller, free from the body of the clasp for only a short distance. The body of the clasp is much more slender than in *marginata*.

Text-fig. 82.



albidisca. $\times 30$.

18. *marginata* de Nicéville, J. A. S. B. iii. p. 70, pl. i. fig. 9.

This species seems to be quite distinct and definite in the ancillary appendages. It belongs to the group in which the dorsal processes possess a spinous process. The clasps are narrow, the spinous extremity is small; the shoulder, usually rounded, is here sharply angular, almost a right angle, so that the, properly outer, margin is transverse to the axis of the clasp.

A specimen in the Tring Coll. is labelled "Penang, Curtis."

19. *limbata* Moore, P. Z. S. 1879, p. 139.

19 a. *placida* de Nicéville.

19 b. *jynteana* de Nicéville.

19 c. *lyce* Grose-Smith.

19 d. *lyseas* Grose-Smith.

(*strophis* H. H. Druce?).

Having examined the appendages of many specimens of each, I

Text-fig. 83.

*marginata*. $\times 41$.

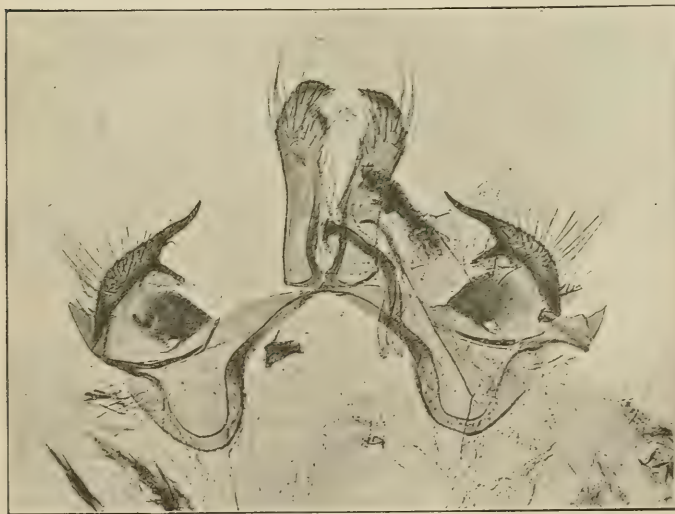
Text-fig. 84.

*marginata* (Penang, Tring Coll.). $\times 42$.

Text-fig. 85.

*limbata*. $\times 42$.

Text-fig. 86.

*limbata* (labelled *lambi*). $\times 42$.

am certain that *limbata*, *placida*, and *lynteana* all belong to one species.

Of *lyce* I have not examined the type specimen, but another one from the same locality that agrees with it in every respect.

Of *lyseas* I have compared the type specimen with forms of *limbata* from several Malayan islands, and have no doubt of its identity.

strophis I have not seen: I throw out the suggestion that it may be a form of *limbata*.

The appendages of this species are so characteristic and different from anything else, that the identity of the specimens examined is unmistakable. The dorsal process has a very long spine, and the spines of the clasps incurving and ending in several teeth (instead of one terminal one) are matched by no other species.

The recognised distribution of *limbata*, *placida*, and *lynteana* does not extend beyond continental India further than Ceylon and Penang.

Besides the type specimens of *lyce* and *lyseas*, the Tring Coll. possesses specimens from S. Flores, S. Celebes, Upper Aroa River, N. G., Lombok, North Formosa, N.E. Sumatra; the latter specimen is a curious dwarf only 23 mm. in expanse.

Most of these specimens are not far from *limbata* in appearance, but those from S. Celebes and Upper Aroa River have wider borders, without approaching or at least reaching the *lynteana* form.

Some remarks on this species in connection with the probably mimetic significance of the *lynteana* form, will be found in Tutt's Brit. Lep. vol. ix. p. 403, and in Proc. Ent. Soc. 1908, p. lxxxi.

Specimens from W.C. Sumatra are in the Druce Coll. They probably deserve a varietal name.

limbata and *placida* from the Moore Collection are both one species; but in the *placida* series the spots beneath the fore wing are distinctly *en échelon*, whilst those of the *limbata* are much more in a continuous line.

19 *e. beretava* Ribbe, Deutsch. ent. Zeitsch., Lep. 1899 (Iris) p. 243, pl. iv. fig. 14.

So far as it is possible to judge from a figure, I think this is probably a form of *limbata*.

20. *strophis* H. H. Druce, P. Z. S. 1895, pl. xxxii. fig. 4, p. 573.

This species has not been examined. I entertain a strong suspicion from the figure (*l. c.*) that like *lyce* and *lyseas* it may be a variety of *limbata*. Mr. Druce's suggestion that it is a seasonal form of *dilectissima* is also possible. The marginal line enclosing the marginal spots, always fairly well marked in all the forms of *limbata* I have seen, is quite wanting. The arrangement of the spots is otherwise very nearly identical in *limbata*

and *dilectissima*. This marginal line varies in *argiolus*, *tenella*, and other species from absence to considerable prominence.

21. *coalita* de Nicéville, J. B. N. H. S. vi. p. 363, pl. F. figs. 12-13.

Assuming a specimen in the British Museum to be, as I fear it is not, correctly named, the appendages, like the fly itself, are very like *dilecta*. The clasps are longer, 1.13 mm. against 0.93 mm., the neck-like portion longer and straighter, *i. e.*, its sides are more parallel and the spinous process is appreciably larger, bolder, and less bent down.

I believe I have not seen a specimen of true *coalita* de Nicév.

These appendages are even more like those of *rona* (*hiagi*) than those of *dilecta*. If it be not *coalita*, it may be a form of *rona*, or else a new species.

Text-fig. 87.



Named *coalita* in B.M. Coll. (probably erroneously). $\times 38$.

22. *cardia* Felder, Sitz. Akad. Wiss. Wien, Math.-nat. Cl. xl. p. 459 (1860).

I have felt some difficulty in discriminating this from *dilecta* Moore, both in the superficial characters and in the appendages, and am still doubtful whether they do not approach each other within the limits of geographical races of one species—*dilecta* being the continental, *cardia* the insular form; though such a distinction does not quite agree with the localities of specimens examined, a specimen from North Borneo being indistinguishable

from *dilecta*, and an almost typical *dilecta* was received from North Luzon (Philippines).

Text-fig. 88.



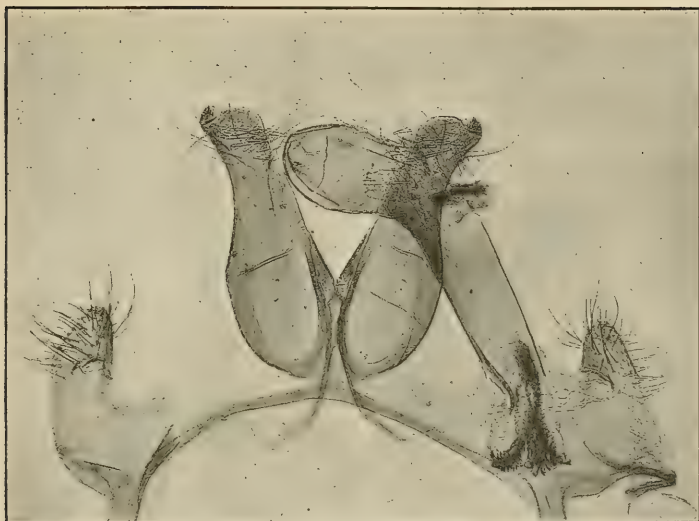
cardia. $\times 43$.

Text-fig. 89.



cardia. $\times 42$.

Text-fig. 90.

*cardia* (New Guinea). $\times 42$.

23. *dilecta* Moore, P. Z. S. 1879, p. 139.

This is a well marked species as occurring in continental India, but I find in the Tring Museum unquestionable *dilecta* from Borneo, Luzon, and Java.

The group to which it belongs is very puzzling, chiefly perhaps because I am loth to recognise here unnamed species of which I know little more than the actual specimen, and the appendages of which differ by comparatively slight but apparently constant differences.

There are some differences in Indian *dilecta*, due possibly to slightly varied softening and pressing in mounting the specimens. 23 *a*, from Borneo, is exactly the same as some Indian specimens, others from India are like 23.

23 *b*. A specimen from Perak has appendages closer to *cossæa* than to anything else, the under side agrees closely with *dilecta*, but the upper side has a darker blue and a dark border along the hind margin.

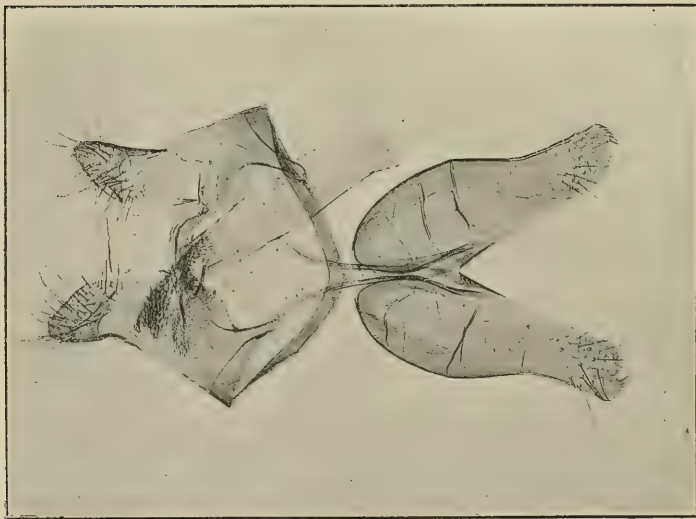
23 *c*. A specimen labelled *cossa* (*cossæa* ?) in the British Museum belongs to this group, but the appendages differ from any named species I have.

My material is too meagre to justify me in naming these two forms.

Text-fig. 91.

*dilecta*. $\times 43$.

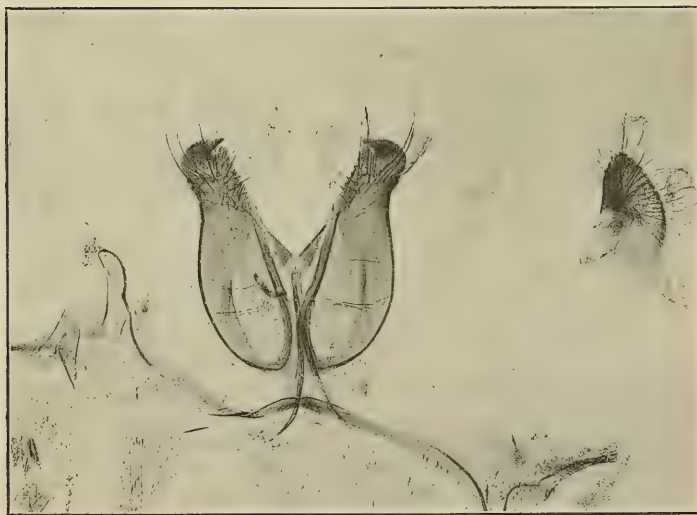
Text-fig. 92.

*dilecta* (Indian). $\times 41$.

Text-fig. 93.

*dilecta* (Upper Aroa River, Tring Coll.). $\times 41$.

Text-fig. 94.

Labelled *cosa*, B.M. $\times 41$.

24. *cossæa* de Nicév. J. Bomb. N. H. S. ix. p. 271, pl. O. figs. 14, 15.

The dorsal process has a rougher (softer) inner and a smoother (harder) outer portion. The clasps are large, very like those of *cardia* or *camenæ*, but with the striking difference that the teeth of the spinous process are directed distad instead of inwards.

Text-fig. 95.



cossæa (B.M.). $\times 28$.

25. *lanka* Moore, Ann. Mag. Nat. Hist. ser. 4, vol. xx. 1877, p. 342.

The spinous process of the clasp lies flat across the end, only the point being free. Along the distal margin the secondary spines are rather sharp and slender. No other species is quite near to it.

26. *rona* Grose-Smith, Nov. Zool. i. p. 572, 1894 (no figure).

26 a. *biagi* Bethune-Baker, is identical with this.

I have compared the type specimens and they agree perfectly, and the coloration and marking of the under side is so different from any other species that there can be no room for mistake. The under side differs from other *Lycænopses*, much as *B. parrhasius* does from *E. argiades*; i. e. the markings, instead of being dark on a pale ground, often black on white, are very pale ochreous on a ground-colour of a not much paler tint.

My photograph of the appendages is from those of the type specimen of *biagi* B.-B.

Text-fig. 96.

*lanka.* $\times 42$.

Text-fig. 97.

*rona (biagi, type).* $\times 45$.

- 26 *a. biagi* Beth.-Baker, P. Z. S. 1908, p. 117, pl. viii. fig. 11.

There is a specimen in the British Museum labelled *coalita* with appendages hardly distinguishable from those of *biagi*.

27. *drucei* Beth.-Baker, Ann. Mag. N. H. ser. 7, vol. xvii. p. 102; P. Z. S. 1908, p. 117, pl. viii. fig. 16.

This well-marked species has appendages belonging to the *dilecta*-group. The dorsal processes are larger than in *dilecta* and the clasps broader, the spinous process much more developed, and with teeth more obviously on its surfaces as well as its margins.

28. *akasa* Horsf. Desc. Cat. Lep. E. I. Co. p. 67, pl. i. figs. 1, 1 *a* (1828).

This species is not likely on its general characters to be confounded with any other. The appendages show it to belong to a rather large group of species in which the terminal spinous process is much reduced in size, but is still fairly developed, turned inwards, but separated by a gap from the inner margin of the end of the clasp.

29. *camenæ* de Nicév. J. Bomb. N. H. S. ix. p. 278, pl. O. fig. 22, 1895 (June ? 1895).

- 29 *a. selma* H. H. Druce, P. Z. S. 1895, p. 573, pl. xxxii. fig. 10 (Oct. 1895).

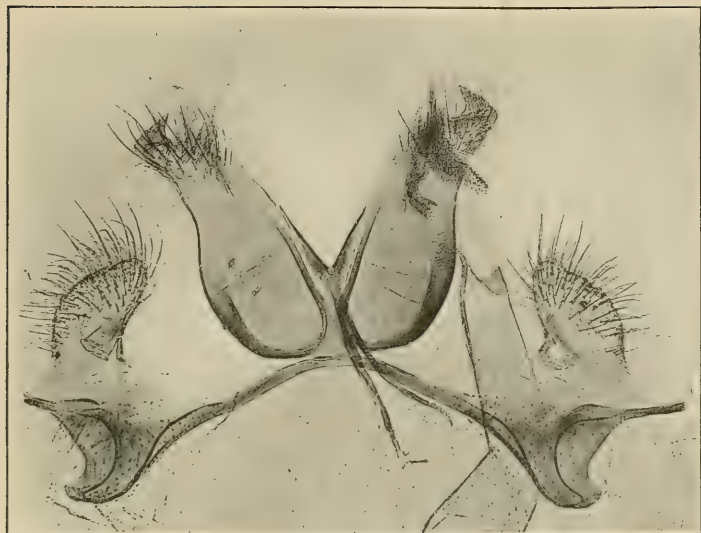
I am unable to see any difference in the appendages of these two forms or indeed in the flies themselves.

There is a specimen in the Tring Collection from Mt. Dulangan, Mindoro, that must be referred to this species. The clasps are rather broader basally than in the typical specimens and the lateral proximal process of the ring is smaller, shorter, and sharper. These differences are, however, quite within the limits of what may be ascribed to geographical variation.

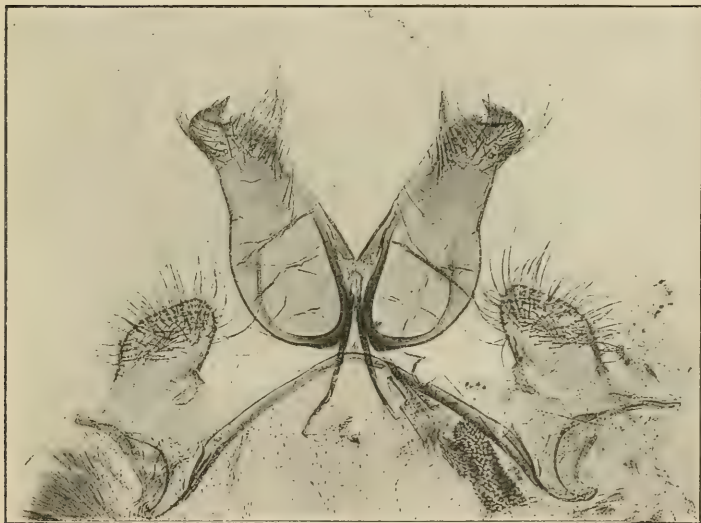
A specimen labelled "Perak—Curtis" differs rather more, and I am doubtful whether it may not be entitled to specific rank; even if so, it is exceedingly close to *camenæ*. The clasps are larger and bolder, and what may be called the neck occurs somewhat higher up. The fly itself is very dark on the upper side, differing from *camenæ* much as *lugra* does from *musina*. The under side is not definitely distinguishable, and this chiefly makes me regard it as a geographical form. As *camenæ* dates from Perak, it may really be that this is actually the typical form of *camenæ*.

A specimen from Sarawak in the Tring Museum is very small and delicate (25 mm. expanse), with upper side very like *dilecta*, except a broader border to fore wing, expanding towards costa.

Text-fig. 98.

*drucei.* $\times 42$.

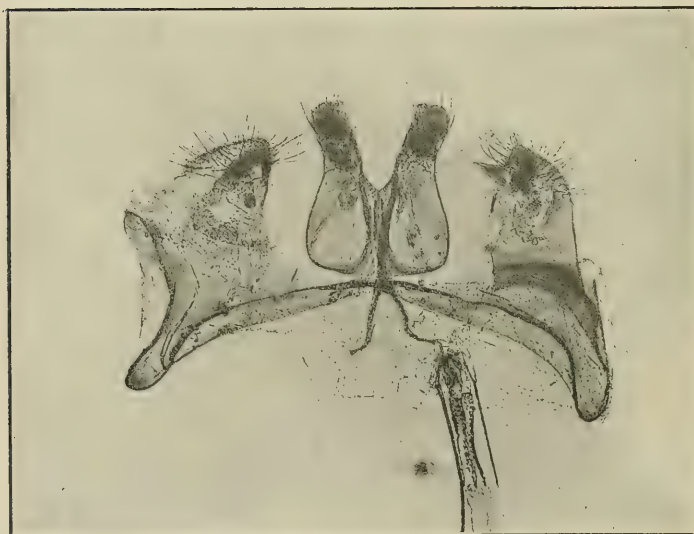
Text-fig. 99.

*drucei.* $\times 42$.

Text-fig. 100.

*akasa.* $\times 42$.

Text-fig. 101.

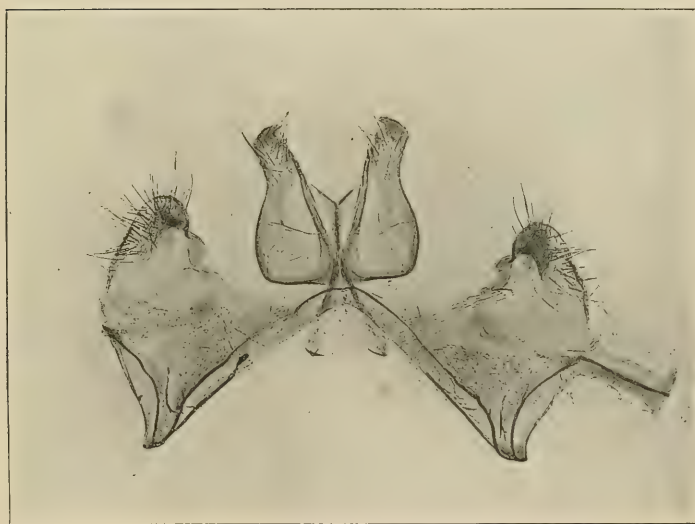
*camenæ.* $\times 42$.

Text-fig. 102.



("Perak—Curtis," Tring Coll.) $\times 43$.

Text-fig. 103.



camenæ (selma, Mindoro, Tring Coll.). $\times 43$.

Text-fig. 104.

*camenae (selma). × 43.*

30. *dilectissima* H. H. Druce, P. Z. S. 1895, p. 571, pl. xxxii. figs. 2, 3.

The appendages are of the *dilecta* (*cardia*) type, smaller and more delicate; length of clasp 0.82 (*dilecta* 0.93). The spinous process more slender and sharper.

The clasp is also of a different form, broadest at the base, whereas in *dilecta* it is broadest $\frac{2}{5}$ of the way from the base and is rounded in an elliptic line to an almost pointed base.

31. *plauta* H. H. Druce, P. Z. S. 1895, p. 574, pl. xxxii. figs. 8, 9.

The clasps have broad transverse ends without any teeth. It is very similar to *transpecta*, with the considerable difference that there are no large teeth on the inner margin as in that species. There is a definite though small soft lower element to the dorsal process.

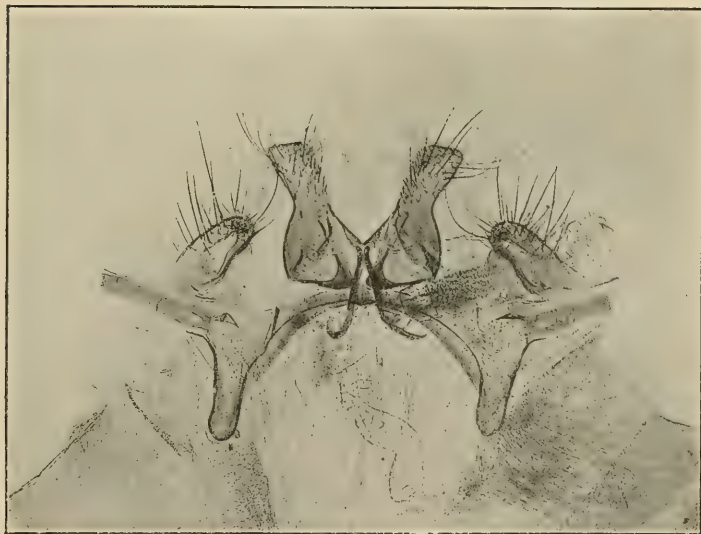
Possibly I have not had true *sonchus*, the specimens examined differing from *plauta* only in the deep yellowish tint of the underside; the appendages were identical with those of *plauta*.

I have a suspicion (from figures and descriptions) that *sonchus* and *plauta* are forms of one species.

Text-fig. 105.

*dilectissima.* $\times 38$.

Text-fig. 106.

*plauta.* $\times 38$.

32. *sonchus* H. H. Druce, P. Z. S. 1896, p. 655, pl. xxix. fig. 4.

See *plauta*.

Text-fig. 107.



sonchus (or *plauta*). $\times 42$.

33. *melæna* Doherty, J. A. S. B. lviii. p. 434, pl. xxiii. fig. 13.

This species belongs to the group in which the spicular process of the clasp is of a length only half that of the extremity of the clasp and lies down so close to the margin that it might conceivably be overlooked.

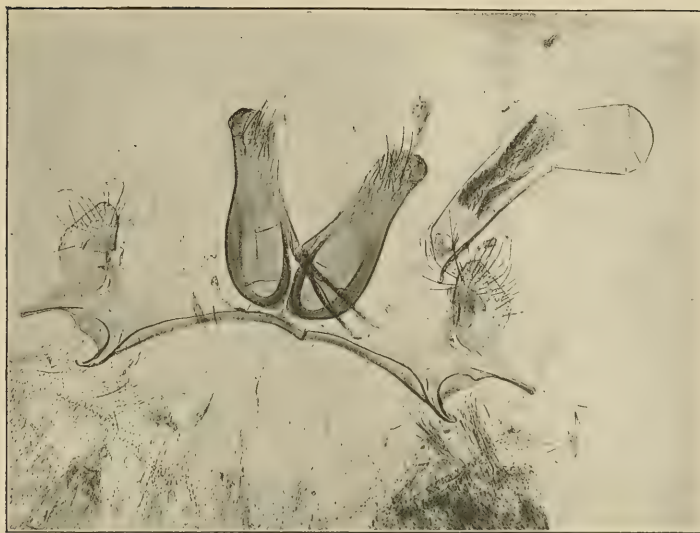
It is certainly very close to *tenella*. The clasps are, however, decidedly longer and a good deal narrower.

34. *tenella* Miskin, Syn. Cat. Rhop. Austr. p. 63 (1891); Pr. Linn. Soc. N. S. W. 1903, p. 144, 1904, p. 771 (G. A. Waterhouse).

I have examined a specimen taken by Dr. G. G. C. Hodgson, near Kuranda, between Naruba and Kuranda, at 1200 ft. elevation, April 1899, and in his collection. As Cairns (at sea-level) is within a score of miles, the locality is no doubt near if not the same as that referred to by Miskin and Waterhouse as "Cairns District." I assume my identification to be correct, as the under-side markings agree exactly with Waterhouse's somewhat diagrammatic figure. The blue has a somewhat greenish tone, not alluded to in Waterhouse's description.

The appendages are slightly smaller but otherwise quite

Text-fig. 108.

*melæna*. $\times 38$.

Text-fig. 109.

*tenella* (*placidula*, Malay Peninsula, Tring Coll.). $\times 44$.

indistinguishable from those of *L. owgarra* (*placidula*) from New Guinea.

I entertain no doubt that they are races of one species. The green tone of the upper surface is a confirmation so far as it goes. The differences are the large amount of white on the upper surface of *tenella*, of which *owgarra* shows no indication in any of the specimens I have seen but in one specimen of *placidula* there are distinct white areas; and that on the under side the markings are much blacker in *tenella*, but the marginal markings have only the marginal spots, at least the arched line that surrounds them in *placidula* (and a majority of *Lycænopside*s) is only faintly indicated.

Text-fig. 110.



tenella (*placidula*, Aroa River, Tring Coll.). $\times 45$.

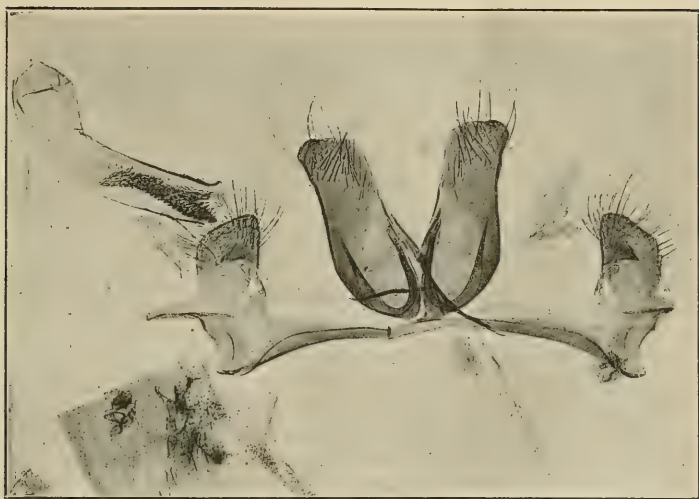
34 a. Var. *placidula* H. H. Druce, P. Z. S. 1895, p. 572, pl. xxxii figs. 6, 7.

34 b. Var. *owgarra* Beth.-Baker, P. Z. S. 1908, p. 116, pl. viii. fig. 17.

The clasps are very short and broad, and very broad at the extremity, the spinous process is minute and fused to the margin of the clasp along the dorsal third of the extremity.

It is very similar to *melæna* and to *singalensis*. The clasp is much broader than in *melæna*, and *singalensis* is larger and has the terminal half of the clasp distinctly narrowed.

Text-fig. 111.

*tenella* (*owgarra*, type). $\times 42$.

Text-fig. 112.

*tenella* (Australia). $\times 45$.

It is no wise related to *placida*. *placidula* has a coloration similar to that of *placida*; *owgarra* has a very green tint, looking at first sight quite a different insect. In the Tring Collection is a specimen, rather deep black-blue, but fairly typical *placidula*, from Gunong Ijan, Malay Pens.; a very similar specimen, except that it possesses white patches (like *puspa*) on all the wings, from Upper Arua River, N. G.; a typical *owgarra* from the same locality, and another *owgarra* from Obi Major.

This shows a very wide range for the species—Malay Peninsula, Moluccas, Borneo, and Australia. The identity of the appendages in specimens from these widely separated districts appears to remove any suspicions one might entertain that *singalensis* and *melana* were varietally related to *placidula*; *singalensis* having the clasps, &c., much larger, and *melana* much narrower.

35. *singalensis* Felder, Verh. zool.-bot. Gesellsch. Wien, xviii. p. 282.

The appendages are very like those of *tenella* (*placidula*), the spinous process being small and almost lost by being pressed down on the upper angle of the extremity of the clasp, which ends in a nearly transverse line. It differs by its larger size, 0.88 mm. long, against 0.62, and by the terminal half being very definitely narrowed into a long neck-like portion. The whole clasp, and especially the base, is much broader than in *melana*.

De Nicéville seemed in much doubt as to this being a "good" species (Butt. Ind. vol. iii. p. 108), and Bingham sinks it as a var. of *huegelii*. *singalensis* is, however, a very distinct species, whilst *huegelii* is a form of *argiolus*.

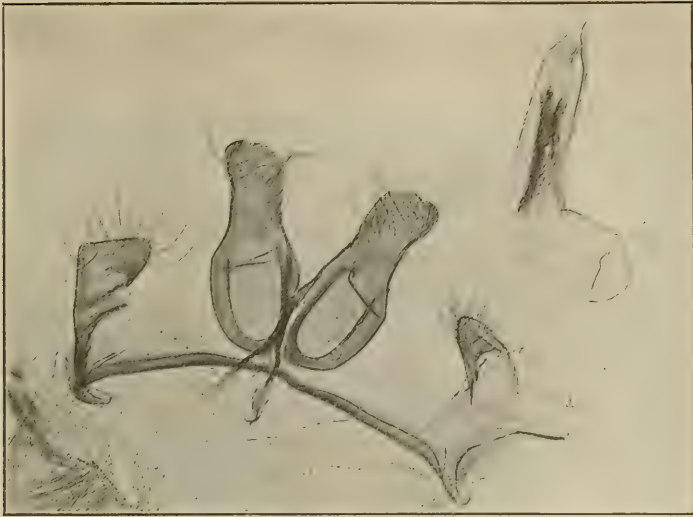
In the Druce Collection there is a series of this species from two localities in Sumatra. They are of a much darker, deeper blue than those from Ceylon, with a strong tendency to a dark border and to spots round the margin of the hind wing; they rather suggest very large, borderless *puspa*, such for example as one in the Tring Coll. from Palawan.

In the Tring Collection is a very pale specimen from Java, looking very much indeed like a large pale *huegelii*, with very white fringes on the hind wing and round the anal angle of fore wing. One would hardly recognise this as the same species as the Sumatran form without the indication afforded by the appendages; the fore wing is even of a different form, being more pointed. The under-side markings differ also, much as those of *strophis* (or *dilectissima*) do from *limbata*.

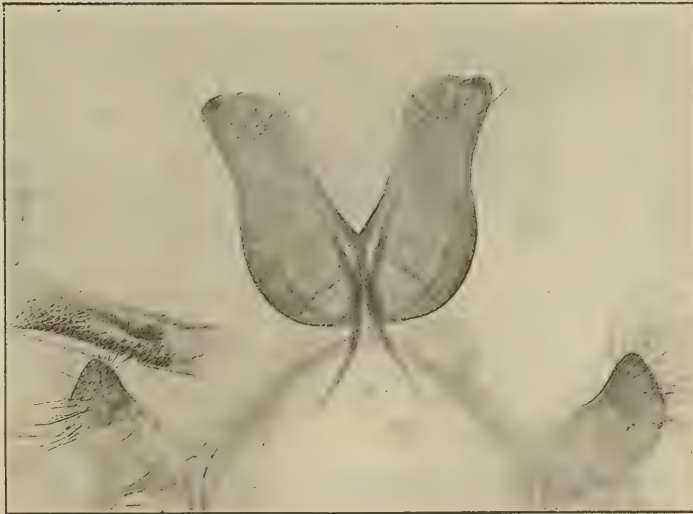
De Nicéville refers to specimens from the Nilgiris; an Indian specimen in the British Museum labelled *singalensis* is *oreas*, previously not known as Indian. *singalensis* is probably not a continental form.

De Nicéville & Elwes refer specimens from Lombok to *huegelii* (J. A. S. B. 1897, p. 695). As *huegelii* almost certainly does not extend to Lombok, these specimens in all probability are *singalensis*. I have not, however, seen them.

Text-fig. 113.

*singalensis* (Ceylon). $\times 33$.

Text-fig. 114.

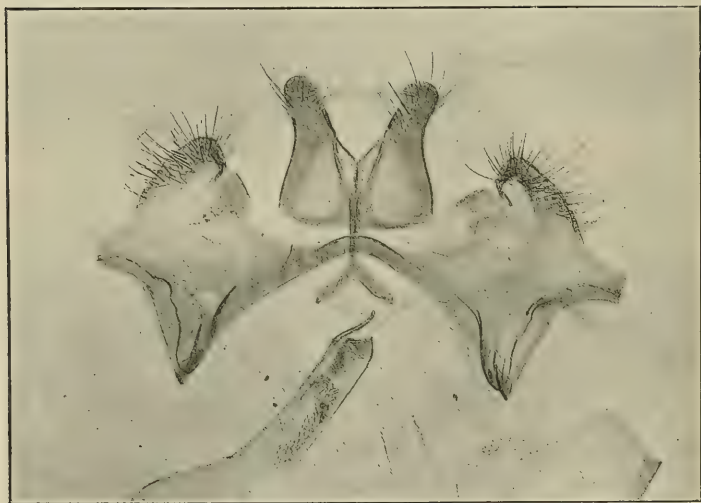
*singalensis* (Sumatra, Druce Coll.). $\times 42$.

The figures of the appendages to same enlargement show the great difference in size between those of *singalensis* and *tenella*; but the one of the former at a less amplification is hardly distinguishable from the latter. The species are probably closely related, but are now quite distinct.

36. *ceyx* de Nicév. J. B. N. H. S. vii. p. 328, pl. H. figs. 6, 7.

The appendages perhaps most resemble those of *plauta*; like it, the clasps have gone beyond *dilectissima* and *placidula* in the gradual dwindling of the spinous process, so that it is quite lost, except a trifling greater chitination of the angle whence it has disappeared. The clasps are very broad basally and joined together for a rather longer distance than usual. The dorsal processes have a well-marked, rather large, rounded elevation as ventral accessory.

Text-fig. 115.



ceyx. $\times 40$.

37. *carna* de Nicév. J. B. N. H. S. ix. p. 274, pl. O. fig. 18.

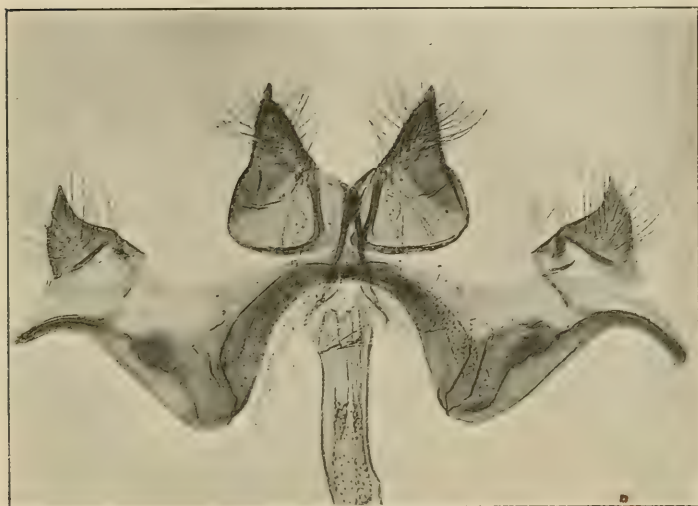
I have not been able to examine this species, described from a unique specimen; the figure suggests to me that it is a Sumatran race of *L. nedda*.

38. *albocerulea* Moore, P. Z. S. 1879, p. 139.

One of the most specialised and remarkable forms. The dorsal processes have developed a terminal (not ventral as in *limbata*, &c.)

sharp point, and the clasps are very broad basally and narrow rapidly to a sharp point, in form something like an inverted pegtop. No other species has anything like either of these peculiarities.

Text-fig. 116.



albocerulea. $\times 41$.

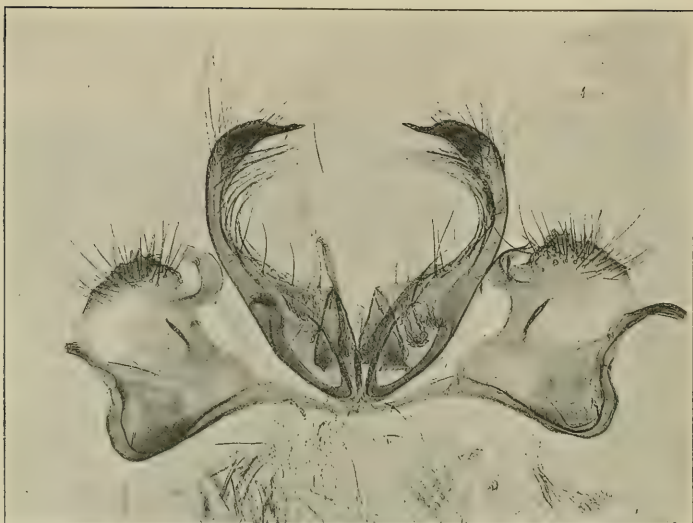
39. *catreus* de Nicév. J. B. N. H. S. ix. p. 276, pl. O. figs. 20, 21.

Butler questions this being a *Cyaniris* because of its neuration, but his objection is, that its neuration is that which is typical of *Lycenopsis*. I question it also because of the somewhat bizarre form of the clasp, which is unlike anything else in the genus, and because of the great development of the accessory ventral process of the dorsal processes, and those dorsal processes themselves possessing several terminal spines; these are small, but are reminiscent of *albocerulea*, to which and to *albidisca* it seems most nearly allied. The ventral accessories of the dorsal processes have here nothing to do with the missing hooks, but are rather the ventral portion of abdominal segment 10, and are probably united by softer tissues across the middle line.

40. *hersilia* Leech, Butt. China, p. 319, pl. xxxi. fig. 16.

I have not heard of a ♂ of this species.

Text-fig. 117.

*catreus.* $\times 38$.

Text-fig. 118.

*Bothrinia nebulosa.* $\times 41$.

41. *deliciosa* Pagenstecher, Ent. Nach. xxii. p. 50; figured Abh. Senck. Ges. xxiii. pl. xx. fig. 8.

I have not seen this insect and can say nothing beyond what Dr. Butler remarks as to its doubtful claim to be a *Lycænopsis*.

BOTHRINIA, n. nom.

Bothria, amended from *Botria* (Rondani), is in use for a dipterous genus, therefore it is necessary to rename *Bothria* (mihi, P. Z. S. 1908, p. 677). I suggest *Bothrinia*.

42. *nebulosa* Leech, Ent. xxiii. p. 43.

This species belongs to the Everids and to the same genus as *chennellii*, viz. *Bothrinia*, and is not a *Lycænopsid* at all.

The appendages have the characteristic dorsal armature, the two (usually) side pieces fused into one in the middle line (as in *Everes*, *Cupido*, &c.), and the clasps with two branches of equal and considerable length. In this case the outer or dorsal branch has a flowing curve not dissimilar to that of the same branch in *Everes*, but curiously both branches are much alike, each ending in three obtuse but sharp spines.

The neuration (anastomosis of veins 11 and 12 of fore wing) is also that of *Everes*, not of *Lycænopsis*.

The row of spots under the fore wing, like those of *chennellii*, are in line; in *Lycænopsis* those above vein 6 are usually more or less moved inwards. This is not a constant character as between Everids and *Lycænopsids*, but there is so much difference in this respect that it may almost be so regarded.

43. *chennellii* is also an Everid (*Bothrinia*), not only not a *Lycænopsis*, but not in the same group of *Lycænids* (see Proc. Zool. Soc. 1908, p. 676).

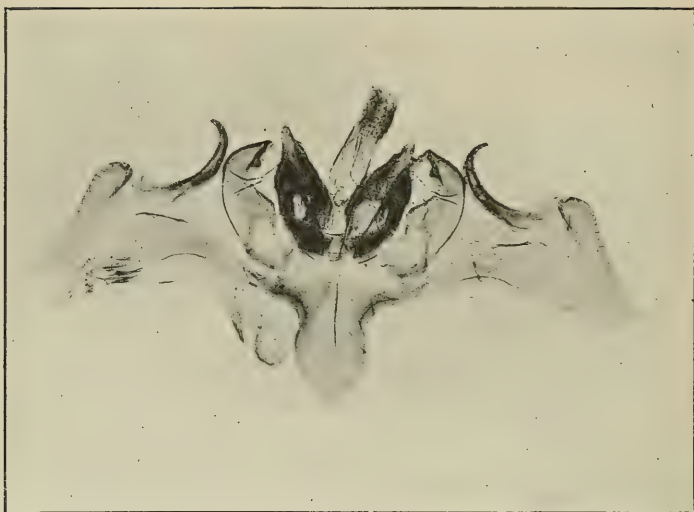
ARTOPŒTES, n. g.*

44. *pryeri*.

Whether on his own or what other authority Dr. Butler (Ann. & Mag. Nat. Hist. vol. v. 1900, p. 442) places this species in *Lycænopsis*, I do not know. I may say with Mr. Murray, who first described it, "It is not closely allied to any species with which I am acquainted." The clasps are so divided that it has the appearance of having two pairs of clasps, a condition I have not noticed in any other (very few, no doubt) *Lycænid* I have examined, though there is some resemblance to it in *Tarucus nara*.

* *αρτοποιος* = baker. (There is already a genus *Artopoia*.)

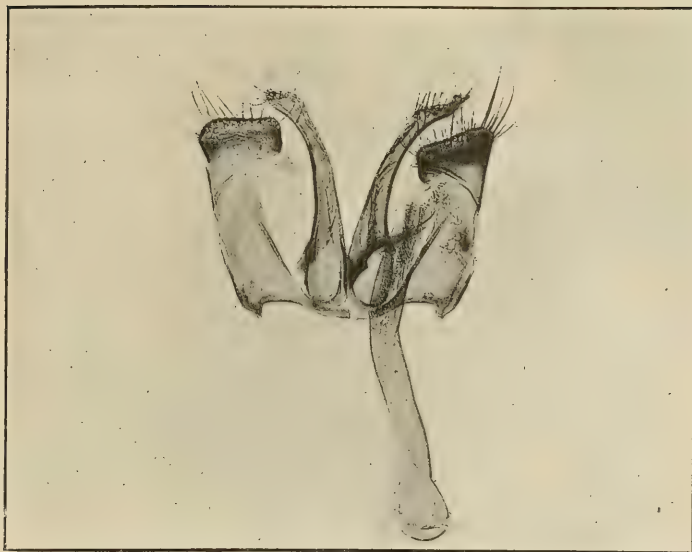
Text-fig. 119.

*Artopöetes pryeri.* $\times 15$.

Text-fig. 120.

*Megisba malaya.* $\times 45$.

Text-fig. 121.

*Neopithecops zalmora.* $\times 45$.

Text-fig. 122.

*Castalius ethion.* $\times 45$.

It certainly does not belong to any genus the male appendages of which I happen to have observed.

The width of the central vacancy in the dorsal armature seems to ally it with the *Lycænopsids*, though the accessory hooks are well developed; and I would propose for it a new genus, *Artopöetes*.

45. *Megisba malaya*, might be a *Lycænopsis*.

46. *Neopithecops zalmora*.

47. *Castalius ethion*.

Both these remind one somewhat of *C. catreus*.

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2. On some Points in the Structure of *Galidia elegans*, and on the Postcaval Vein in Carnivores. By FRANK E. BEDDARD, M.A., F.R.S., F.Z.S., Prosector to the Society.

[Received March 18, 1909.]

(Text-figures 123-131.)

The death of a specimen of this Madagascar Viverrid on February 21 last has enabled me to supplement my account of *Galidictis striata** with some notes upon its ally *Galidia elegans*, of the anatomy of which there is at present but little knowledge. The two genera are undoubtedly very closely allied, but nevertheless there are some differences which fully justify the generic separation of the two, and which include facts of some little interest as a contribution to the anatomy of the Viverridæ. I have endeavoured to examine into all the matters which are known to be of importance from a systematic point of view, and the excellent condition of the specimen fortunately permitted a careful study of some of the veins.

§ *External Characters.*

The external characters of *Galidia* are for the most part known and are referred to by Mivart in his account of the genera of *Æluroidæ*†. He observes that "the anus does not seem to open into any cutaneous depression." I find that this statement, made perhaps somewhat tentatively‡, is perfectly correct. I also agree with Mivart in finding no prescrotal glands.

Carpal vibrissæ are present, as in so many other Carnivora§.

It will be noted that the absence of prescrotal glands differentiates the genus *Galidia* from *Galidictis*, in which they are present, but that both agree in the absence of a cutaneous pouch into which the anus opens. The anus is large in *Galidia*, as is also the case with *Galidictis*.

§ *Alimentary Canal.*

In my paper upon *Galidictis* I have recorded the fact that in a skull of *Galidia elegans* examined by me the first premolar was present on both sides, there being thus—so far as this specimen was concerned—no difference from the allied *Hemigalidia*. I find, however, from an examination of the example of *Galidia elegans* which forms the subject of the present communication to the Society, that the tooth in question is absent, and from both

* "On some Points in the Structure of *Galidictis striata*," P.Z. S. 1907, p. 803.

† "On the Classification and Distribution of the *Æluroidæ*," P. Z. S. 1882, p. 135.

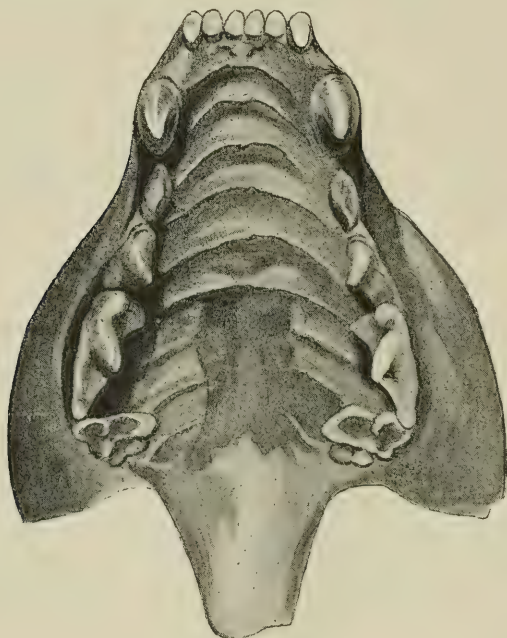
‡ It is queried in the definition of the subfamily *Galidictinæ*, *loc. cit.* p. 189.

§ Beddard, "Observations upon the Carpal Vibrissæ in Mammals," P.Z.S. 1902, vol. i. p. 127.

sides of the jaw. The species therefore obviously varies in this peculiarity. There is, moreover, a considerable diastema between the canine and pm. 2, so that a small pm. 1 which has not emerged may be present in the jaw.

The *ridges of the palate* in *Galidia elegans* are reproduced in the accompanying figure (text-fig. 123). There are six complete semicircular ridges perfectly symmetrical, of which the first is not so extensive laterally as the rest. This runs across between the

Text-fig. 123.



Palate of *Galidia elegans*.

two canines. The next ridge corresponds to the diastema, and the remaining four to the three premolars. Thereafter follow four half-ridges on each side, but the details will be best understood by a reference to the figure referred to.

The *tongue* has been already partly described by Mivart*, who has recorded a well-defined patch of spiny papillæ upon the middle of the anterior half of that organ. This, as I have already pointed out, is exactly what is to be found in *Galidictis*. There is, however, no further description of that organ, which I show in the accompanying drawing (text-fig. 124).

* P. Z. S. 1882, p. 498.

The *papillæ circumvallatæ*, as shown in that drawing, are only two, right and left, as in *Nandinia*, the Genet, *Hyæna striata*, *Proteles**, three or even more (*Arctictis*) being met with in other Viverridæ. There is nothing remarkable in the size or shape of these papillæ.

Text-fig. 124.



Tongue of *Galidia elegans*, dorsal view.

On the right are eight of the strong anterior papillæ more highly magnified.

The *fungiform papillæ* are scattered over the dorsum of the tongue between the *papillæ circumvallatæ* and the anterior patch of strong papillæ; they are chiefly massed in the actual middle line of the tongue, and there is no narrow middle line free from them as in the Civet. The arrangement of these papillæ seems,

* *Loc. cit.* p. 500. I can confirm Dr. Mivart in the case of *Hyæna striata*, where there are distinctly only two of these papillæ.

in fact, to be very like that of *Nandinia*. The anterior patch of conical papillæ is like that of *Galidictis*, which has been figured by myself*, and of about the same extent. A few of the papillæ are shown more highly magnified at the side. Their tips show a tendency to become bifid and to be separated from the rest of the papillæ. In these characters they are not unlike the conical papillæ of *Galidictis*.

The *frænum* of the tongue has a free fold of mucous membrane near its attachment to the floor of the mouth; but this fold does not form a continuous fold anteriorly, but is prolonged into two elongated processes on either side of the *frænum*, apparently differing from the Genet†.

The *stomach* seems to me to be as described by Dr. Mivart‡, and I have nothing to add to his remarks.

The *intestinal tract* is quite typically Carnivorous, but there are various details of structure to which it is necessary to refer in comparing *Galidia elegans* with its allies, and especially with *Galidictis*. The duodenum forms the usual C-shaped loop enclosing a part of the pancreas, from the end of which (where the pancreas bends up towards the liver parallel with the portal vein) arises the ligamentum recto-duodenale as in other Carnivora. This ligament has a curious relation to the hepato-caval ligament, which, if it be more general than I suppose, is at least not universal. The latter ligament, arising from the inner edge of the caudate lobe of the liver, is attached as usual to the postcaval vein, but a considerable portion of it strays on to the mesocolon and becomes continuous with the recto-duodenal ligament, the two forming together a semicircular fold of watch-pocket form (see text-fig. 125). I found the same arrangement to be much more marked and symmetrical in *Nandinia binotata*. At the opposite extreme is *Procyon lotor*, in which the short ligamentum hepato-cavale is attached only to the postcaval vein.

As is the case with other terrestrial Carnivora, the *colon* and *rectum* form a very short tube, which is perfectly straight in *Galidia*. It is decidedly shorter than in *Galidictis*, where I have described a rudimentary transverse colon, and where, if the colon were straightened out, it would reach forward as far as the diaphragm. In *Galidia* the colon lies perfectly straight, and only reaches up to the anterior end of the left kidney, at which point the cæcum arises. The total length of the colo-rectum is $4\frac{3}{4}$ inches, something short, therefore, of that of *Galidictis*. I have made notes on the form of the colon in a number of Viverrids, which I may here compare with that tube in *Galidia* and *Galidictis*. In *Crossarchus fasciatus* there is as well a developed transverse colon as in *Galidictis*. *Suricata tetradactyla* agrees with the two last-mentioned Æluroids. If the colon were fully straightened out, the cæcum would be seen to arise a long way in front of the left

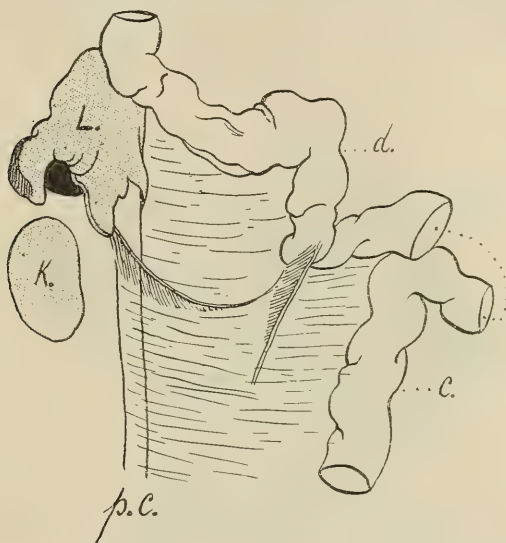
* P. Z. S. 1907, p. 806, text-fig. 210.

† Mivart, P. Z. S. 1882, p. 499, fig. 3 B.

‡ P. Z. S. 1882, *loc. cit.*

kidney. The species *Herpestes smithii* shows the same bending of the colon over to the right side of the body. On the other hand, in *Paradoxurus hermaphroditus* the colon is short and quite straight, and there is no trace of a transverse colon, such as exists in the types already referred to. The cæcum of this animal, in fact, lies pretty well in the middle of the body. In the closely-allied *Paradoxurus niger* the conditions are the same, and the cæcum originates only just in front of the left kidney. *Viverra civetta* is also quite like *Paradoxurus*. *Genetta rubiginosa* has this

Text-fig. 125.



Caudate lobe of liver, duodenum, and adjacent structures in *Galidia elegans*.

- c. Colon. d. Duodenum, from which arises recto-duodenal ligament partly inserted upon mesocolon and partly continuous with hepato-caval ligament as explained in text. K. Right kidney. L. Caudate lobe of liver, from the lowermost process of which arises hepato-caval ligament. p.c. Postcaval vein.

peculiarity exaggerated, for the cæcum arises from the colon considerably behind the left kidney. While, therefore, these facts seem to justify the separation of Viverrines and Herpestines among the Viverridæ, they leave the affinities of the alleged subfamily *Galidictinæ* doubtful; and it is remarkable that while *Galidictis* is Viverrine in its scent-glands, it is Herpestine in its colon, while, on the other hand, *Galidia* is Herpestine in the absence of scent-glands and Viverrine in the condition of the colon, which is perhaps what is to be expected in a subfamily

believed to be an ancient Viverrid assemblage. The relationship of the colon to the left kidney is shown in the accompanying figure (text-fig. 126). That drawing also illustrates the cæcum shown from both sides. It is necessary to exhibit the cæcum on both sides because of the differences in the cæco-colic ligaments on the two sides of the cæcum. The cæcum itself, independently of its mesenteries, has been already figured by Dr. Mivart*, and quite correctly except that it is represented as straighter than it is in nature. This is, however, to be accounted for by the cutting of the various ligaments which attach the cæcum to adjoining regions of the gut. It is clear, however, from this figure that *Galidia* agrees with *Galidictis*† in possessing a long and thus Herpestine cæcum. In my figure of the cæcum of *Galidictis* I

Text-fig. 126.

Cæcum and adjacent structures of *Galidia elegans* viewed from both sides.

The left-hand figure shows the position of the cæcum with regard to the kidney, which is partly covered by the colon.

- a. Median frænum of cæcum. b. Lateral cæco-colic ligaments.
c. Lymphatic gland.

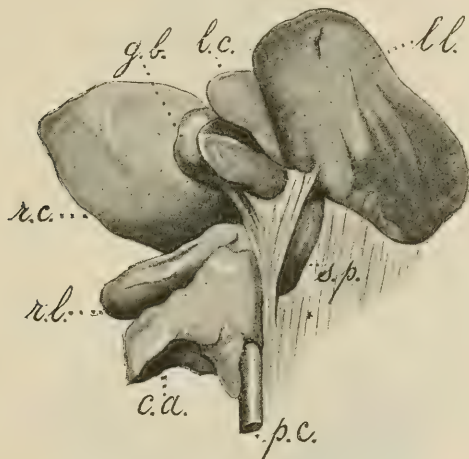
have contrasted this Viverrid with *Herpestes fulvescens*, in which latter the frænum of the cæcum—the anangious ligament binding it to the ileum—is continuous up to the very top of the cæcum. In *Galidictis* this is not the case, and the actual tip of the cæcum is not thus attached; the frænum does not run so far. *Galidia* agrees entirely in this particular with *Galidictis*. I may take this opportunity of mentioning that *Suricata tetradactyla* does not agree in this full extension of the ligament to the very tip of the cæcum with *Herpestes*. I also pointed out in the paper referred to that in addition to the median anangious frænum the cæcum

* P. Z. S. 1882, p. 508, fig. 8 C.

† P. Z. S. 1907, p. 805, text-fig. 211.

of these animals is fixed to the gut by two minute lateral ligaments which bear blood-vessels. These were particularly obvious in the example of *Galidia elegans* which I have dissected, since they were loaded with fat. It is noteworthy that the median membrane being anangious had not received a coating of fat. These membranes, one on the left and one on the right side, are almost microscopic, as is shown in my drawing of *Galidictis* *. *Galidia elegans* shows an interesting difference, for in that Carnivore the membrane on the right side is very much larger than that on the left, and joins the median anangious frænum. The figure (text-fig. 126) also shows a lymphatic gland imbedded in the right-hand lateral mesentery, the presence of which appears to be very typical in these Carnivora. I have already referred to its existence in *Galidictis striata* and *Genetta vulgaris*. I have also found it in *Suricata*. The left-hand mesentery is quite small.

Text-fig. 127.

Liver of *Galidia elegans*, abdominal surface.

c.a. Caudate lobe. *g.b.* Gall-bladder. *l.c.* Left central lobe. *l.l.* Left lateral lobe.
p.c. Postcaval vein. *r.c.* Right central lobe. *r.l.* Right lateral lobe.
s.p. Spigelian lobe.

The *pancreas* has the usual form of the figure 6 so general in Carnivora. The circular portion of the gland lies within the duodenal loop. The *liver* is represented from the abdominal surface in the accompanying text-figure (text-fig. 127). It does not differ greatly from that of *Galidictis* †, with which it may be compared.

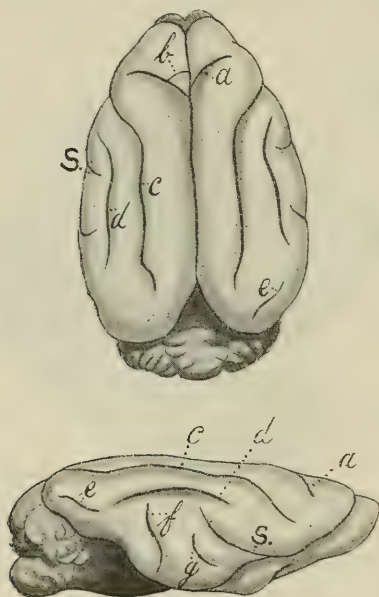
* P. Z. S. 1907, p. 808, text-fig. 211 B.

† P. Z. S. 1907 p. 809, text-fig. 212.

§ *Brain.*

I figure the brain of *Galidia elegans* in two aspects (text-fig. 128), from the dorsal side and a lateral view, which together expose all the fissures at any rate of one side. There is, however, no great asymmetry in the brain of this Viverrine such as demands the additional representation in the figure of the left side. On the whole, the brain agrees very closely with that of *Galidictis**, which I have already figured and described at some length, comparing it with the brain of allied forms. Viewed from above, the general outline of the brain does not present any marked differences from that of *Galidictis*, and it is of about the same size.

Text-fig. 128.

Brain of *Galidia elegans*, dorsal view and lateral view.

- a. Crucial sulcus. b. Precrucial sulcus. c. Lateral sulcus. d. Suprasylvian.
e. ? Ectolateral sulcus. f, g. Ectosylvian fissures (see text). S. Sylvian.

The *crucial* sulcus is long, as it is in *Galidictis* (where I have contrasted its length with the shortness of the same fissure in *Viverra civetta*), and is also slightly asymmetrical in relation to its fellow. The right-hand sulcus is a little in advance of the left. It is curious that while the same furrows in *Galidictis* are also

* P. Z. S. 1907, p. 814, text-fig. 216.

slightly asymmetrical, the asymmetry is precisely the reverse. In this region the brain of *Galidia* shows an interesting feature not shown in the brain of its ally *Galidictis*. On the left side of the brain, and on the left only, as is shown in the text-figure, there is what certainly appears to be a precrucial sulcus, such as is figured by Dr. Elliot Smith in *Viverra**, and is well known to be very characteristic of the Arctoid division of the Carnivora†.

The lateral sulcus seems to be in all probability a conjoined lateral and coronary sulcus, as I have given reasons for believing to be the case with the lateral sulcus of *Galidictis*. There is no great difference between these fissures in the two Carnivores now under consideration. Posteriorly in *Galidia* the sulcus bends inwards and then outwards, ending therefore in a semicircular outline. It may well be that this is an indication of a vestige of an ento-lateral sulcus such as is figured by Elliot Smith in *Herpestes pulverulentus*‡.

There is, moreover, just a faint indication of an anterior prolongation to the inside of the lateral sulcus from the angle which the latter makes when it bends outwards. I could find no definite ansate sulcus in the brain of *Galidia*.

The *suprasylvian* sulcus ends posteriorly at the level of the inward bending of the lateral fissure. Anteriorly also it does not extend so far as does the lateral fissure, in both these points differing from *Galidictis* and from *Herpestes* as figured by Elliot Smith.

The *sylvian* complex of fissures differed slightly on the two sides of the body. The right side is represented in the annexed figure (text-fig. 128). The fissure which I have lettered "*f*" seems to me to correspond with the postsylvian fissure of *Herpestes*, in which case perhaps "*S*" is not really the sylvian fissure proper, but an anterior ectosylvian, while "*g*" is a posterior ectosylvian. On the other hand, on the left side of the brain, while *S* retains the same position and relations, the two fissures "*f*" and "*g*" form only one fissure, the lower part of "*f*" being absent, and the upper part joining, or very nearly joining, "*g*." The arrangement here is, in fact, very like that of the left side of the brain of *Galidictis* figured by myself. There is in favour of the former interpretation of the furrows in question the fact that the furrow which I have lettered "*S*" does not reach the rhinal furrow at quite the right point of a true sylvian fissure. This, I think, will be apparent after an inspection of my drawing. It seems, on the whole, to be the most reasonable course to regard the true sylvian fissure as not present, but to consider the fissure which I have lettered *S* to correspond to the similarly-lettered furrow in Dr. Elliot Smith's figure of the Hyæna's brain§, which he refers to in the text as "the so-called 'Sylvian fissure,'" and which is followed by two fissures in the temporal region, as in *Galidia*.

* Cat. Mus. Roy. Coll. Surgeons, vol. ii. ed. 2, 1902, p. 249, fig. 122.

† Mivart, Journ. Linn. Soc., Zool. vol. xix. 1886.

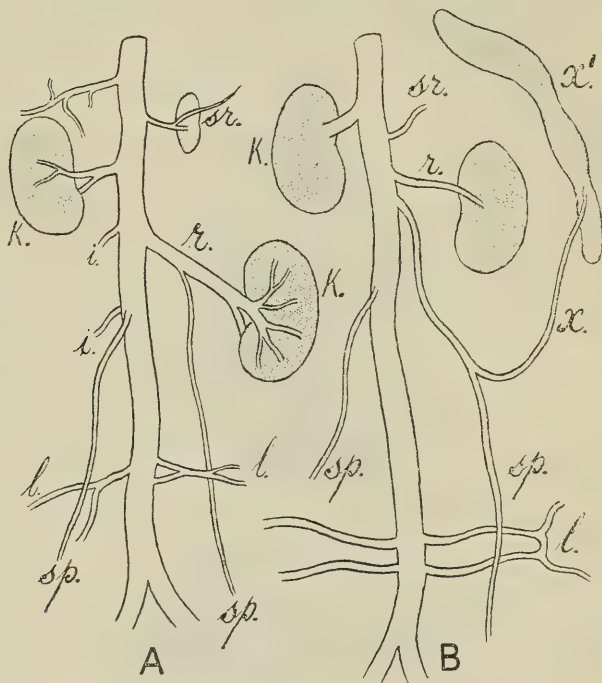
‡ Loc. cit. p. 254, fig. 625.

§ Loc. cit. p. 257, fig. 130.

§ *The Postcaval Vein and its Branches in Galidia
and in some other Carnivora.*

These veins (text-fig. 129 A) in the specimen of *Galidia* which I dissected were turgid with blood, and therefore in a very favourable condition for anatomical study. I take this opportunity of comparing them with those of other Carnivora which I have dissected lately. The large postcaval vein is quite normal in position—that is, it lies to the right of the aorta as in the majority

Text-fig. 129.



Postcaval vein and branches in *Galidia elegans* (A) and *Nandinia binotata* (B).

i. Intercostal veins. *l.* Lumbar veins. *K.* Kidneys. *r.* Renal veins. *sp.* Spermatic or ovarian veins. *sr.* Suprarenal veins. *x.* Splenic branch of ovarian. *x'.* Spleen.

of mammals. The renal veins are asymmetrical, that of the right kidney entering the postcaval above the entrance of the left renal. This asymmetry is, it will be perceived, the exact reverse of that of *Galidictis**, where the left renal enters the postcaval higher

* P. Z. S. 1907, p. 811, text-fig. 213.

up than the right. Each renal vein, when close to the kidney, divides into two branches, one lying above the other, which supply respectively the dorsal and ventral side of each kidney, over the surface of which they ramify, as is so usually the case among the *Æluroidæ*. This difference of symmetry in the renal vein is correlated with the fact that in *Galidia* the left suprarenal flows into the postcaval independently of the left renal, whereas they join in *Galidictis*. Furthermore, there are no additional renal veins such as are present in *Galidictis*. The spermatic veins arise as in *Galidictis* (and indeed most mammals), the left from the left renal, the right from the postcaval vein considerably below the entrance into the latter of the renal veins. Two intercostal veins flow into the dorsal surface of the postcaval between the left renal and the right spermatic vein, each of them, however, very nearly corresponding in the point of entrance to the point of entrance of those two veins. The postcaval receives lower down two lumbar veins on each side, as in *Galidictis*. The exact disposition of these veins in *Galidia elegans* is as follows:—On the left side there are two veins, each of considerable width, which lie respectively above and below the corresponding artery, which therefore emerges from the aorta between them; before passing respectively anteriorly and posteriorly the two veins are joined by a bridge which passes over the artery just before it divides. On the right side the two lumbar veins unite just before opening into the postcaval, and they are not united by a bridge distally.

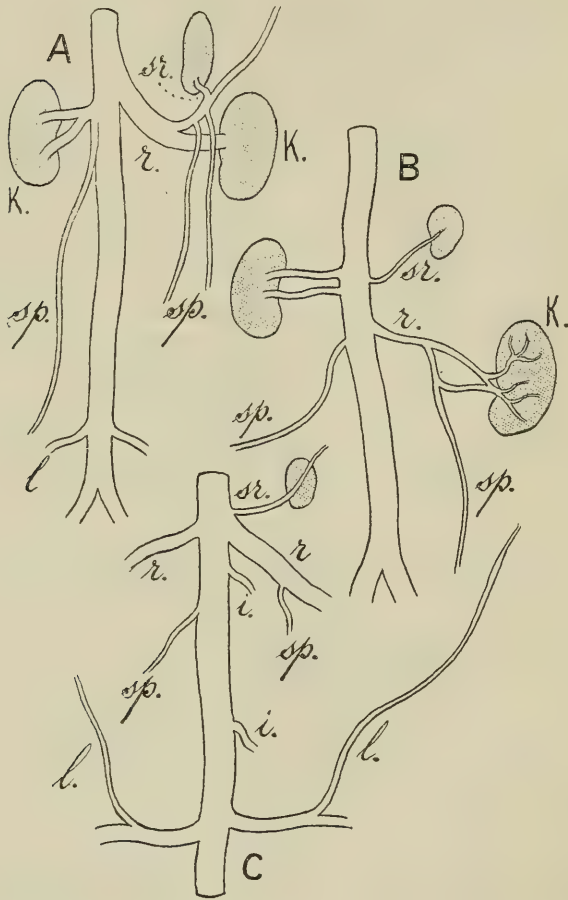
In an example (text-fig. 130 B, p. 488) of *Suricata tetradactyla* I found a closer agreement with *Galidictis* than with *Galidia*. There were two renal veins on each side, arising and ending precisely as I have figured them in *Galidictis*. The right ovarian vein, though pouring its contents into the postcaval itself as in most other Carnivora, reached that vein rather nearer to the left renal than in either *Galidictis* or *Galidia*.

In another example of *Suricata* (text-fig. 130 A) the conditions were in many points the same, but in others a little different. On the right side the renal veins were two, though ultimately reaching the postcaval by a common trunk. The renal was single on the left side, and this vein was more symmetrical with its fellows of the right side than in the first specimen. There was in this specimen an unusual origin of the left ovarian vein. The right was as in the last specimen. The suprarenal of the left side was, as often in Carnivores, an important parietal vein to begin with, of which the actual suprarenal twig is only an affluent. Into the conjoined parietal and suprarenal, before it flows into the renal vein, open two parallel ovarian veins (as in Marsupials), which thus cross over the left renal and do not open directly into it. The two lumbar veins posteriorly are single and symmetrical in their points of opening into the postcaval.

A dissection of two examples of *Crossarchus fasciatus* showed that the ovarian veins were disposed precisely as in *Galidia* and *Galidictis*. The renal veins were single.

In *Herpestes smithi* I found differences of detail which are worthy of record. The right and left spermatic veins had the same relations to the postcaval and left renal respectively as in the other *Æluroid Carnivora* already dealt with. The position

Text-fig. 130.



Postcaval vein and branches in *Suricata tetradactyla* (A, B) and *Cercoleptes caudivolvulus* (C).

Lettering as in text-fig. 129.

of the right vein was more like that which I have described here in *Suricata*. The renal veins were single, and the left supra-renal entered the postcaval independently of the left renal.

The lumbar veins were in some respects like those of *Galidia*, and in other respects differed. They resemble those of *Galidia* in the fact that there are two veins on each side, and that while those of the left side open separately into the postcaval those of the right side join before doing so. There is, however, this important difference between the two animals in respect of these veins. In *Herpestes* the postcaval has already divided into the two iliacs, into each of which therefore the lumbar really open. In *Galidia* the vein is a single vein at the points of entry of the lumbar, and does not divide until later. It should also be mentioned that the renals are asymmetrical with the asymmetry of *Galidia*. With this is associated the separate entry into the postcaval of the left suprarenal already mentioned. I say "associated," since in one specimen of *Crossarchus* where the left renal and the left suprarenal entered the postcaval separately, there was an asymmetry between the two renals; whereas in a second example, where the left renal and suprarenal entered the postcaval together, it was at a point exactly opposite to the entrance of the right renal.

I have also collected some notes on Viverrine *Æluroids*, and have already figured in *Genetta vulgaris** the veins with which I am now dealing. In *Paradoxurus hermaphroditus* the two renal veins were asymmetrical, the right entering the postcaval above the left. The spermatic veins showed an exaggeration of the condition described above in *Suricata*. The left spermatic vein as usual enters the left renal; the right spermatic vein, as is also quite usual with Carnivora, enters the postcaval directly but very far forward—on a level, in fact, with the entrance of the left renal. The two lumbar veins are, as in *Genetta vulgaris*, single veins on each side. They enter the postcaval asymmetrical, and are asymmetrical in two ways. In the first place, the left vein enters rather more anteriorly than the right. In the second place, the right vein enters the postcaval after it has bifurcated to form the iliacs. The left vein enters the postcaval in its undivided region. It is to be noted that the corresponding arteries are also correspondingly asymmetrical in the position of their exits from the aorta. I found two examples of the African Civet Cat (*Viverra civetta*), both of them males, to differ slightly in the branches of the postcaval. In one the veins were exactly as I have described them in *Paradoxurus hermaphroditus*, except that the lumbar were quite symmetrical in position and that they both entered the postcaval before its bifurcation. In the other the right spermatic vein entered the postcaval some way behind the renals, and the lumbar, though symmetrical, were two on each side.

Of *Nandinia binotata* (text-fig. 129 B, p. 486) I have examined some of the veins with which I am concerned in the present communication in two individuals, both males. In one of these the

* P. Z. S. 1907, p. 812, text-fig. 214.

two renals were pretty symmetrical as to their point of entry into the postcaval. The left spermatic entered the left renal as usual, and the right spermatic entered the postcaval as usual some way further down. The second example showed a very remarkable variation—for the condition which I am about to describe must be, I think, a variation, though I possess no positive notes or sketches of anything similar in the first-described example*. In this specimen the suprarenal, renal, and spermatic veins were all separate from each other up to their entry into the postcaval vein, which they entered in the order named. The spermatic vein, however, was an unusually thick vein (for a spermatic vein), and bending backwards ran for some little way parallel to the postcaval, thus suggesting a persistent left cardinal vein. Presently it divided into two, the smaller continuing in the same straight line as a quite slender spermatic vein. The larger trunk bent round to the left, and after giving off some branches to the omentum ended in the spleen. There can be no possible doubt about the course of this vein: it was full of blood, and could be followed throughout with perfect ease. Furthermore, I do not think that any affluent from the spleen reached the portal system. All the blood thence derived flowed along the vein which I have just described. This, again, perhaps favours the supposition of the persistence of a left cardinal vein. On the other hand, this view is not supported by the position of the orifices of the lumbar veins. These veins, in fact, of both sides open into the postcaval. They are symmetrical, and there are two veins on each side, as in many of the other Carnivora already described in the present communication. Moreover, on the left side, and the left side only, the two veins were joined by an anastomosis as in *Galidia*.

I shall now give an account of these same veins in a number of genera of Arctoid Carnivora.

In *Procyon lotor* the renals arose symmetrically. The left infrarenal entered the postcaval independently of the left renal. The right ovarian vein entered the postcaval some way below the renals, into the left vein of which pair the left ovarian vein poured its contents. There is thus no difference from the arrangement met with in the majority of *Æluroid* Carnivores, except in the symmetry of the renals, which is not a very common character of the *Æluroides*.

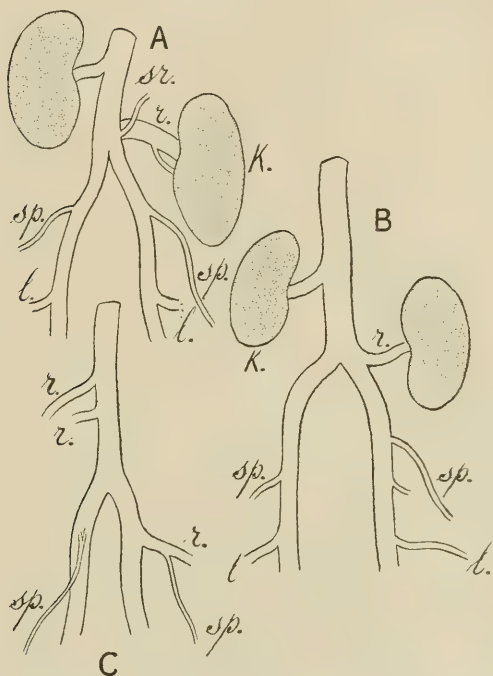
In *Cerculeptes caudivolvulus* (text-fig. 130 C, p. 488) there was the same symmetry of the renals; while the position of the ovarian veins was also the same as in *Procyon*. The left suprarenal joined the left renal just before the latter debouches into the postcaval. The lumbar veins were single and slightly asymmetrical, the left being in advance of the right. Each lumbar gives off a marked superficial branch running anteriorly dorsal to the

* In a specimen dissected subsequently (26. V. 9) there was no splenic vein opening into the postcaval.

kidney. Between the renals and the lumbar the postcaval received two intercostal veins.

I have examined four individuals of *Ictonyx capensis*—three of them females and one male—which showed certain individual differences. In one of them (text-fig. 131 B) the postcaval was double postrenally, after the fashion of the Armadillos and Anteaters*. The division was prolonged upwards to just anteriorly to the entrance of the left renal vein. The right renal vein entered the postcaval higher up, where it was a single vein.

Text-fig. 131.



Postcaval vein and branches in *Mellivora signata* (A), *Ictonyx capensis* (B), and *Mephitis mephitis* (C).

Lettering as in text-fig. 129.

The ovarian veins were symmetrical and arose each from its own separate postcaval. This was also the case with the lumbar veins, which were single veins. In the second female the conditions were of the more "normal" Carnivorous type. The renals were symmetrical, the postcaval was not divided, and the ovarian veins had the very asymmetrical origin found in nearly all Carnivora.

* Hochstetter, Morph. Jahrb. xx. 1893.

In a third, also a female, the renal veins were asymmetrical, but it was otherwise like the second specimen just described. The fourth example, a male, was just like the last specimen in all the veins the arrangement of which I studied.

I have preserved the skin of the "abnormal" example and am able to compare it with the skin of the second specimen which I have described and with two others. There are, however, no reasons for regarding the specimen as of a different species or race. It is certainly a good deal smaller, which may of course ultimately prove to be a racial or even specific character. But I am unable to press this conclusion at present.

Three examples of *Meles meles* differed among themselves. In one there was what I term the typical arrangement. In a second the left ovarian vein, instead of opening on to the renal, had moved down and debouched directly into the postcaval, but above the entrance of the right ovarian vein. In this example, moreover, the renals were symmetrical. In a third example the renals were also symmetrical. But in this specimen the orifice of the right ovarian vein had moved anteriorly and had come to open into the postcaval in common with the left ovarian.

In a female example of *Mephitis mephitis* (text-fig. 131 C, p. 491) I found a condition of the postcaval and its affluent veins almost exactly like that of the first specimen of *Ictonyx* of the series just described in one important particular, but differing in some other details. The point of resemblance between these in other respects closely allied Mustelines was the division of the postcaval vein postrenally. The division, however, in *Mephitis* is more marked than even in *Ictonyx*. It extends, in fact, further forward beyond the entrance of the left renal in *Mephitis*. Thus the left renal pours its blood into the left half of the postcaval, while the right renal communicates with the undivided anterior region of the postcaval. There are, however, two renals on the right side, though only one on the left. The ovarian veins arise symmetrically in relation to their position in the body, but asymmetrically in relation to the veins with which they are connected. The left-hand vein is as usual a branch of the left renal vein; the vein of the right opens as usual into the postcaval, but at a point exactly opposite to the entrance of the left renal and therefore from the right-hand subdivision of the postcaval. It is noteworthy that here, as in some other cases, the right ovarian vein is not a lateral affluent of the postcaval; it flows into that vein on its ventral surface.

In *Bassaricyon alleni*, the veins of which I have not referred to in my account of the general anatomy of this animal*, the dissection of a second specimen enables me to describe the disposition of the postcaval and its branches. The two renals are perfectly symmetrical and the ovarian veins are disposed in the usual asymmetrical fashion. The lumbar veins are double, but unite just

* P. Z. S. 1900, p. 661.

before entering the single postcaval; neither pair is connected by an anastomosis.

In three examples of *Nasua rufa* the branches of the postcaval were practically identical. In all of them the asymmetry of the renals was unusual, the left lying more anteriorly than the right. From the left arises, as usual, the left ovarian (or spermatic), while the right-hand vein enters the postcaval below this point.

In the Otter (*Lutra*) the renals were quite symmetrical and the ovarian veins quite as usual.

In *Helictis personata* the left ovarian vein was connected quite as usual with the left renal vein. But before entering it the ovarian vein received a small branch from the body-wall in the region of the kidney. This vein appears to me to be very possibly the equivalent of the second lower and smaller renal veins which I have figured in *Galidictis*. The right ovarian vein, as usual, communicates directly with the postcaval.

In *Ursus syriacus* the ovarian veins presented an arrangement which I have not found in other Carnivora. Both were directly connected with the corresponding renal vein. Nor were the renal veins symmetrical, as perhaps might be inferred from this fact. The right was in advance of the left, as is so commonly the case not only in the Order of the Carnivora but in Mammals generally.

It is hardly possible to extract from the foregoing series of facts any very plain cut-and-dried definitions of the several groups of Carnivora derived from the characters of the postcaval vein, such as is possible for example with the Marsupials. One can only point out tendencies to the development of a particular type in one group and of another type in another group of Carnivores. Thus it is the Arctoid Carnivora, and possibly chiefly the Musteline division of that group, in which the double post-renal postcaval vein is to be met with*. The Arctoid genera, in their wide distribution, nearly plantigrade feet, only at most slightly specialised carnassial teeth, and with their non-retractile claws, lie at a lower level than the *Æluroides*. This result may be perhaps taken into consideration along with the condition of the postrenal section of the postcaval. In the same direction also points the more usual symmetry in the position of the renal veins; these very frequently, more frequently than in the *Æluroides*, open into the postcaval opposite to each other. Again, it is more common in this subdivision of the Carnivora for asymmetry to be shown in the position of the spermatic or ovarian veins. No

* I am indebted to Mr. Burne for the information that in the Walrus the postcaval vein is double from the level of the renal veins. This observation was made upon the viscera of a young Walrus which died in the Society's Gardens, and was acquired by the Royal College of Surgeons. This condition in the Walrus is quite possibly normal, for Mr. Burne has directed my attention to the fact that Dr. Murie (Trans. Zool. Soc. vii. p. 431) found the vein double in the individual dissected by himself. This doubling of the postcaval behind the kidneys is not, however, distinctive of the Pinnipedia, for Murie figures (Trans. Zool. Soc. viii. p. 546, woodcut fig. 4) a single postcaval in the Patagonian Sea-Lion.

absolute line of distinction can, it is true, be drawn between the Arctoidea and the Æluroidea in the arrangement of these veins. But whereas among the Æluroidea only a few forms (e. g., *Suricata*, *Herpestes smithi*) can be mentioned in which the veins are approximately symmetrical, there are more Arctoidea in which this symmetry occurs, viz. in the species *Mephitis mephitis*, *Ictonyx capensis*, *Ursus syriacus*. Moreover, in *Ursus* an absolutely "Marsupial" disposition of the spermatic veins is to be met with, where both are connected with the renal veins. Finally, the lumbar veins are more usually restricted to a single vein upon each side of the body in the Arctoidea; while they are prevalently double in the Æluroidea. That this feature is more archaic than that which characterises the Æluroidea can hardly be said. I merely dwell upon the fact that there is a tendency to the establishing of this difference between the two groups. But in dwelling upon these facts it must not be forgotten that some Arctoidea are apparently exactly like some Æluroids in the disposition of these veins.

Doubtless it cannot be said that the comparisons and contrasts amount to a great deal. But they have at least an interest in connection with the variations in the arrangement of the postcaval and its branches in the Common Cat, "*Felis domestica*." The veins of this animal have been lately studied in so large a number of specimens as 605*. This large number probably gives some real idea of the range of variations in these veins. In no less than 23 examples the author found in the posterior region a double postcaval, such as I have described in *Ictonyx* and *Mephitis*. In 7 there was a left postcaval, instead of the normal Eutherian right. In others, again, the spermatic veins, instead of their normal asymmetry which is certainly the prevalent disposition in the Carnivora, as I have pointed out, both entered the postcaval directly.

§ Other Blood-vessels.

The cerebral arteries of *Galidia elegans* are like those of other Carnivora, differing only from those of certain forms in details. There is at the posterior end of the medulla a strongly marked rhomboid of arteries, as in many other Carnivora. This is associated with a large anterior spinal artery and vertebral arteries. The latter are single where they join the lateral angles of this rhomboid, and not double as they are in *Helictis personata*†. The middle cerebellar arteries are two on one side and one on the other (left); but the latter divides into two very shortly after its emergence from the basilar artery. It is to be noted that these

* W. Darrach, "Variations in the Postcava and its Tributaries, as observed in 605 Examples of the Domestic Cat," Amer. Journ. Anat. vol. vi. 1907, Anat. Rec. p. 30.

† Beddard, "On the Anatomy of *Helictis personata*," P. Z. S. 1905, p. 22, text-fig. 8.

arteries arise behind the sixth nerves. The anterior cerebellar arteries arise very shortly after the bifurcation of the basilar. Excepting for the fact that the cerebellar arteries are strictly paired, I found the arteries of the Common Otter precisely as has been just described for *Galidia*.

Dr. Tandler* has figured the cerebral arterial system of the Seal, and has represented the anterior spinal as of large size, as is the case with many Carnivora including those to which I have referred in the present communication. In a specimen of the Common Seal which I dissected some time since this was not the case. The anterior spinal was very slender, and communicated with the two very stout vertebrals by two very slender branches. The middle cerebral artery is single, and lies, as I have mentioned in *Galidia*, behind the origin of the sixth nerve†. The circle of Willis is joined anteriorly by the anterior communicating artery. I am unfortunately not quite certain about this part of the cerebral arterial system in *Galidia*; but I believe it to be like that of *Helictis* figured by myself‡.

The system of cerebral arteries in an example of *Cryptoprocta ferox* may be compared with that of the types already described by others § as well as by myself. The first remarkable fact is the asymmetry of the arteries at the end of the medulla, which, however, is very possibly an individual peculiarity, as the asymmetry in the cerebral arteries of *Hyrax* described by myself || proved to be later ¶. Both the anterior spinal and the vertebral arteries are stout. Although the main paired middle cerebellar artery lies behind the sixth nerve, there is a slender branch on the right side which lies in front of it. The anterior cerebellar artery lies just behind the bifurcation of the basilar. The arrangement of the anterior communicating artery and of the anterior cerebrals generally is very much as I have figured in *Viverra civetta***.

I do not think that the cerebral arterial system of *Hyæna crocuta* has been described. The specimen which I have had the opportunity of examining showed some differences from other Carnivora. Beginning as before with the posterior end of this arterial system, it is to be noted that the vertebral arteries are large—which is a general character of the group. On the other hand, there is no definite rhomboid-shaped arterial area at this point—i. e., at the posterior end of the medulla—which is so characteristic of Carnivores. There are, in fact, two anterior spinal arteries, smaller than the vertebral, which run back at least for some little way without joining. I have no evidence, in fact, that they do ever join; for

* "Zur vergl. Anatomie der Kopfarterien bei den Mammalia," Denkschr. k. Akad. Wiss. Wien, Bd. lxxvii. 1899.

† I have already (P. Z. S. 1904, vol. i. p. 191) directed attention to the varying position of these arteries with reference to the sixth nerve.

‡ P. Z. S. 1905, p. 22, text-fig. 8.

§ See also Bertha de Vriese, "Sur la Signification morphologique des Artères cérébrales," Arch. d. Biol. xxi. 1904, p. 357.

|| P. Z. S. 1904, vol. i. p. 187, text-fig. 18.

¶ P. Z. S. 1909, p. 166.

** P. Z. S. 1904, vol. i. p. 194, text-fig. 21 B.

the brain was severed from the spinal cord some little way behind the medulla before I commenced its study. Into the circle of Willis the carotids enter rather far back; and in front of them, but still behind the sylvian artery, there was an ophthalmic artery, as I presume it to be, on the right side only: I found no trace of one on the left. A remarkable feature about the circle of Willis of this Hyæna is the great length of the anterior communicating artery, which lay in a loose circle posteriorly. Generally speaking, this artery is short and straight.

The *iliac arteries* in the specimen of *Galidia* were not symmetrical, as they are stated to be by Mivart* in other *Æluroidea*. The two larger external iliacs are produced by the terminal final bifurcation of the aorta. From the left of these arises a trunk which continues for a short distance in the same straight line as the aorta and then divides into the two internal iliacs. It is perhaps worth while mentioning that I found an asymmetry the precise converse of this in a Squirrel (*Sciurus prevosti*). In this animal the aorta ended in the same way, by dividing to form the two external iliacs. From the right of these arose a branch which shortly divided to form the two internal iliacs.

3. On the Postcaval Vein and its Branches in certain Mammals. By FRANK E. BEDDARD, M.A., F.R.S., F.Z.S., Prosector to the Society.

[Received April 8, 1909.]

(Text-figures 132-139.)

In studying the venous system of a large number of Mammals at the Prosectorium at the Zoological Society's Gardens I have relied entirely upon naturally injected veins. And indeed veins turgid with their own blood are better for this study than artificial injections. For, in the first place, error is absolutely eliminated, inasmuch as no injection-fluid can escape and give rise to apparent branches which have no existence; and, secondly, it is always possible to press upon the contained blood, and thus ascertain the reality of anastomoses, which can be readily missed in a defective artificial injection. Moreover, in animals which have died with their veins full of blood, minute branches which might be missed in other specimens, and which might not be reached by an artificial injection, are plainly revealed. I have, therefore, in the present communication only dealt with those out of the many specimens which I have dissected during many past years that were in a good condition for this particular study, and have rejected the data derived from anæmic examples. Thus I have every reason to believe that the facts which I now bring before the Society are accurate. It is now well known

* P. Z. S. 1882, p. 515.

that the venous system of Mammals, even as concerns the large trunks, is subject to considerable variation. It is, therefore, not without usefulness merely to record the facts alone as a contribution to this department of anatomical study. I have, however, referred to previous work upon the subject, and have endeavoured to summarise the present state of our knowledge upon the postcaval veins of Mammals and their branches. The important work of Hochstetter*, and more recently of McClure† and others, upon the venous systems of Edentates and Marsupials has attracted a great deal of attention to the venous system, and has been productive of definite ideas as to the arrangement of the several trunks in these animals. I am able to confirm, and in some respects to slightly extend, the work of these writers.

In making observations and in deducing conclusions from the arrangement of the veins in Mammals it is requisite to bear in mind the variability of these vessels, which appears to be greater than that of the chief arterial trunks. Recently the variability of the postcaval and its branches has been studied by McClure in the Virginian Opossum (*Didelphys marsupialis*)‡, by William Darrach in the common domestic cat§, and by H. von W. Schulte in various Marsupials||, while I myself have recorded¶ some variations among the Carnivora. I am able in the present communication to note some variations as well as normal arrangements. But inasmuch as variation occurs so frequently in so fixed a type as the Carnivore *Felis*, a specialised race of a specialised group, it is probable that variation occurs pretty well everywhere. But in the centre of this variation lies a mean which can be derived from the study of many examples.

§ *The Postcaval Trunk and its Branches in various Orders of Mammals.*

The Marsupials show a very constant condition in that the postcava lies medianly ventral to the aorta, so that on dissection the aorta is not seen, being completely covered by the postcava. The discovery of this very nearly universal characteristic of Marsupials we owe, as Hochstetter has pointed out**, to Owen††. After examining *Macropus giganteus*, *M. bennetti*, *Phascologomys vombat*, *Phalangista vulpina*, *Didelphys lanigera*, *D. pusilla*, *Phascologale penicillata*, *Belideus sciureus*, *Cuscus* sp., *Hypsiprymnus* sp., and two pouch-young of *Petaurus tiganoides*, Hochstetter found that this generalisation held good for all those species with

* "Beiträge zur Entwicklungsgeschichte des Venensystems der Amnioten," Morph. J.B. 1893; and "Monotremen und Marsupialier," in Semon's 'Forschungsreisen in Australien,' Bd. ii. Lief. 3, 1896.

† Amer. Journ. Anat. vol. ii. 1903, and vol. v. 1906.

‡ *Loc. cit.*

§ "Variations in the Postcava . . . in 605 Examples of the Domestic Cat," Amer. Journ. Anat. vol. vi. 1907, Anat. Rec. p. 30.

|| *Ibid.* p. 34.

¶ "On the Anatomy of *Galidia*," P. Z. S. 1909, p. 486.

** *Loc. cit.* p. 626.

†† 'The Anatomy of Vertebrates,' vol. iii. p. 552.

the exception of the last-named, *Petaurus taquanoides*. In that species he found that the postcava lay to the right "as in the Cat." My own observations quite bear out those of Hochstetter, to whose list I am able to add a few species dissected by myself which that anatomist had not the opportunity of examining. I have never met with the condition which characterises *Petaurus taquanoides* in any Marsupial.

In addition to these types, McClure, as has already been mentioned, has dissected many examples of *Didelphys marsupialis*, as well as the Wombat and *Petrogale* sp.^{*}, while Parsons has reported upon *Petrogale xanthopus*†, and Parsons and Windle upon *Macropus rufus*‡. The figure of *Petrogale* given by McClure§ quite agrees with that of *Macropus bennetti* illustrating Hochstetter's remarks ||. In neither of these figures is the anterior spermatic veins represented, though McClure states that they are present, as also in the Wombat. They are furthermore represented by the last-mentioned anatomist in *Didelphys*¶, and the anastomosis between the anterior and posterior spermatic veins clearly shown. Inasmuch as McClure has remarked that in the Wombat the spermatic veins also open in the neighbourhood of the kidneys, as well as into the postcaval trunk, I do not quite understand his saying, in a later paper, that "In a number of adult Australian Marsupials, however, the spermatics do not open into the postcava, as in *Didelphys*, but open into it at the base of the renal veins, as in *Phascolumys wombat*, or into the renal veins themselves, as in *Notoryctes typhlops*," as observed by Miss Sweet**. It would appear, however, that McClure does not allow the value of a spermatic vein to a vessel often slender which does pass between the gonads and the renal vein; for he writes thus of *Didelphys*: "In none of the adults examined did the spermatics open into the renals, although an anastomosis between the latter and the spermatics was *invariably* †† present, on each side, in the form of a small vein which followed the ureter." As a matter of fact, I have myself generally found two such small veins which were frequently large veins fully as important as what I term the posterior spermatic veins, which open behind them into the postcaval itself. Nor, indeed, is any difference of size shown by McClure in the plate‡‡ which illustrates the main venous trunks (as well as the arterial) of *Didelphys virginiana*.

In a female *Trichosurus vulpecula* I found that the postcaval and its various branches were arranged as follows:—The asymmetrical renal veins not only lacked symmetry in their plan of opening into the postcaval trunk, but also in their number, for

* Amer. Journ. Anat. vol. ii. 1903, p. 388.

† P. Z. S. 1896, p. 683.

‡ J. Anat. Phys. vol. xxxii. 1898, p. 119. This paper deals mostly with osteology, muscles, and viscera. But the authors mention the ventral position of postcaval.

§ Loc. cit. p. 388, fig. vi.

|| Loc. cit. p. 626, fig. 13.

¶ Amer. Journ. Anat. vol. v. 1906, p. 199.

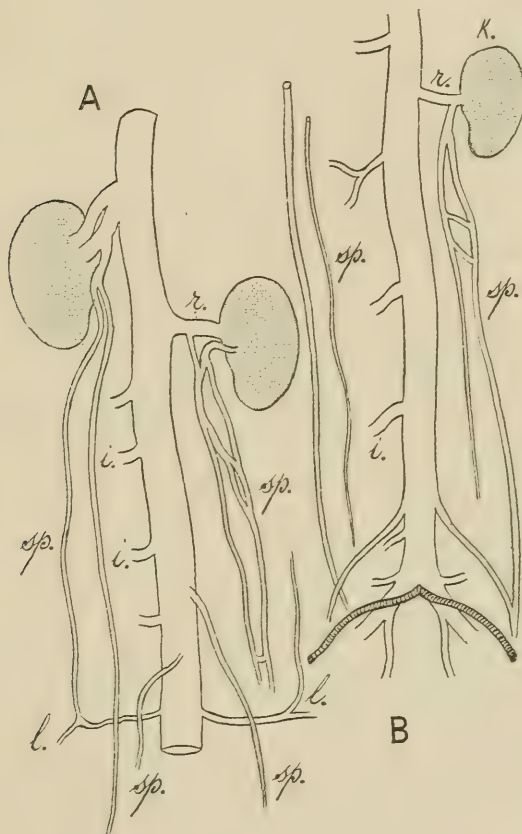
** Proc. Roy. Soc. Victoria, vol. xvii. 1904, pt. i.

†† Italics Dr. McClure's.

‡‡ Amer. Journ. Anat. vol. v. 1906, pl. i.

on the right there were two of these veins of equal and considerable size. On the left only a single renal vein debouched into the postcava. As is usual (? universal) among Marsupials both renal veins give off an ovarian vein, in addition to that pair which flow directly into the postcaval. On the right side a single

Text-fig. 132.



Postcaval vein and its branches in *Trichosurus vulpecula* (A) and *Trichosurus fuliginosus* (B).

i. Intercostal veins. K. Kidney. l. Lumbar veins. r. Renal veins.
sp. Spermatic or ovarian veins.

vein opened into the lower of the two renal veins; at a little distance from its point of opening into the renal vein this ovarian vein divided into two. Of these the outer branch opened into the lumbar parietal some little distance away from the opening

of the latter into the postcaval. The inner vessel, running of course parallel with the outer branch, crossed over the lumbar and reached the ovary. There was no junction between this vein and the main ovarian trunk, which I shall describe directly as opening straight into the postcaval, except perhaps quite distally, where the smaller branches of both these veins may anastomose on and about the ovary.

On the left side the veins in question were somewhat different. There are, however, two of them, as on the right side. Anteriorly these two veins cross and anastomose with each other more than once, and one of them appears to be connected directly with the kidney of the left side. Posteriorly the two vessels are again united by a short transverse trunk on a level with the posterior ovarian veins. Both these vessels appear to reach the ovary. With the left lumbar parietal vein is connected a forwardly running branch, as on the right side. It occupies an entirely corresponding position, but does not form either of the ovarian veins just described. It gradually dies away anteriorly. Between the left renal vein and the lumbar already spoken of are four intercostal veins. On a level with the last of these and rather asymmetrically (the left being in front of the right) enter the posterior ovarian veins.

Of a few other Marsupials I have less complete notes upon these various veins. In a specimen of *Trichosurus fuliginosus** the two renals were very asymmetrical, the left being much below the right in its point of entry into the postcaval; the two anterior spermatic veins were present, and the left certainly, and the right probably, flowed into each renal. Whether they anastomosed with the posterior spermatics I am not certain, but I think that they did not. The latter veins were also asymmetrical, the right opening into the postcaval below the left.

A second example of *Trichosurus fuliginosus* showed some additional features of which I had not made notes in the first example. The asymmetry of the posterior ovarian veins seems to me to be explained by this specimen. When the right vein is carefully examined it is seen not to enter the postcaval, where it appears to enter, *i. e.* just opposite to the entry of the left ovarian vein. From this point it runs forwards, closely adhering to the postcaval vein until it reaches the next intercostal vein, in common with which it opens into the postcaval. Whether there is or is not a connection also with the intercostal lying next behind the one just referred to—and I am inclined to think that there is not—we have here, as I believe, a retention of a more anterior section of the postcardinal than is retained on the left side. This appears to be shown by the course of the vein strictly parallel to and in close contact with the postcaval (*i. e.* the right subcardinal,

* In all the species which I describe here the postcaval lies below (*i. e.* accurately above, on a dissection from the ventral surface) the aorta. This fact, clearly unusual among Marsupials, was first discovered by Owen, as both Hochstetter and McClure have pointed out in their memoirs.

or both cardinal collaterals*) and its connection with a vein of the body-wall.

On the left side two vessels run, one on each side of the ureter to the renal vein of that side into which they opened after fusing into one vein. Lower down, these vessels were connected by several cross-anastomoses. The outer of the two, which is the real anterior ovarian vein, anastomoses with the posterior ovarian vein only just in front of the ovary. The inner and more slender of the two vessels could be distinctly seen to pass dorsally of the posterior ovarian, and to follow the ureter to the bladder. On the right side the outer (ovarian) vessel did not fuse with the posterior ovarian, but passed dorsally to it. I did not follow the more slender vessel beyond the posterior ovarian. Between the left renal vein and the posterior bifurcation of the postcaval were four stout intercostal veins, of which two lay above the entry of the right ovarian, which enters the postcaval in common with the third of these four veins. The lumbar parietal veins flow into the common iliac vein on either side. The ovarian arteries escape from the aorta just at the bifurcation of the postcaval, as shown in text-figure 132, p. 499.

In *Pseudochirus peregrinus* the veins in question are much like those of *Trichosurus vulpecula*, but show differences of detail. The renals are but slightly asymmetrical. Into each renal opens a vein at right angles, which is compounded of two running along the ureters. These become separate at a very short distance from the renal vein. They appear to cross the spermatic vein without forming an anastomosis with it, and they do not anastomose with each other. The spermatic veins are symmetrically paired and flow into a postcava some way below the renals. There are two intercostal veins lying between the influx of the spermatics and the left (lower) renal. On one side of the body I noted an anterior lumbar parietal vein, which passes along the lower border of the kidney at right angles to the anterior spermatic vein, from which it arises close to the renal vein. The posterior lumbar parietal veins flow perhaps rather into the iliacs than directly into the postcaval stem, but are just at the junction of the two.

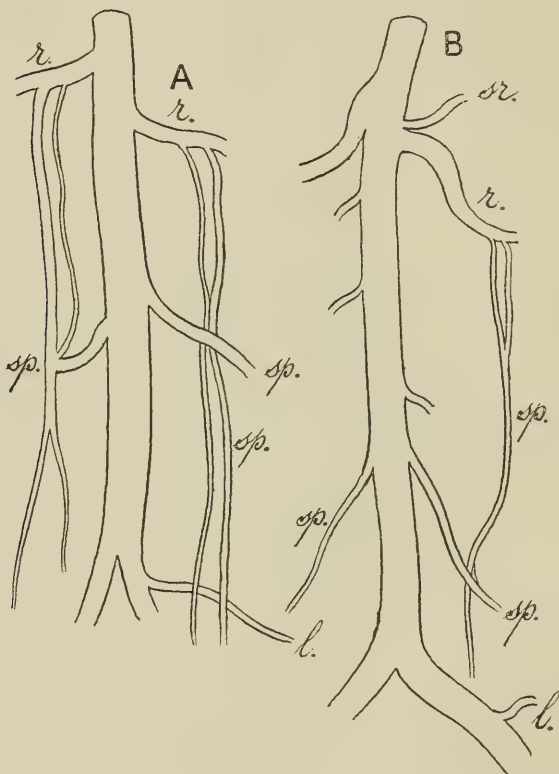
In *Onychogale lunata* both anterior and posterior spermatics were present, though I am uncertain as to an anastomosis between them. The posterior spermatics were very asymmetrical, the left being much above the right. The latter, indeed, joined the postcaval only just in front of the bifurcation to form the iliac veins. The renals were also as usual asymmetrical.

In *Onychogale frenata* the typical Marsupial arrangement was met with in all its essentials. There were nevertheless slight differences in detail between these two Marsupials. The renal veins although asymmetrical were not very much so, the right-

* It is impossible to fix accurately, without embryological data, which part of the postrenal section of the postcaval is here dealt with.

hand vein being only slightly above the left. The individual dissected was a rather large young one, but from the pouch; but it does not appear likely that it would have retained any foetal characteristics. On each side the usual two veins open into the renal. One of these, the outer renal, seems to open directly into the kidney, as I have noticed in *Trichosurus vulpecula*. The two veins do not form any anastomoses that I could detect, and neither of them become connected with the posterior spermatic veins. The latter are quite symmetrical. The left suprarenal vein opens into the renal vein just before the latter debouches into the postcaval.

Text-fig. 133.



Postcaval vein and its branches in *Dasyurus manglei* (A) and *Onychogale frenata* (B).

sr. Suprarenal vein. Other lettering as in text-fig. 132.

In another specimen of *Onychogale frenata* there were some slight differences. This example was an adult female with a small young one in the pouch. The renals were perhaps rather

more asymmetrical. Both renals, it ought to be stated, were single veins, as in the last specimen. The suprarenal of the left side entered the postcaval just at its junction with the left renal. The posterior ovarian veins were nearly but not absolutely symmetrical, the right-hand vein being just a shade above the left. The anterior ovarian veins were double on each side, and certainly anastomosed with the posterior ovarian on each side, where they passed dorsal to it. The two veins—closely following the ureters, as is the case in other Marsupials—were connected to each other by numerous anastomoses, and the conditions were the same on both sides of the body. Between the entrance of the renal vein (left) and the point of entrance of the two posterior ovarian veins I counted three rather slender intercostal veins, of which two were distinctly on the right side of the postcaval, and one (the last) as distinctly on the left side. The lumbar parietal veins opened into the iliac a considerable distance from the bifurcation of the postcaval, and were directed anteriorly in their course.

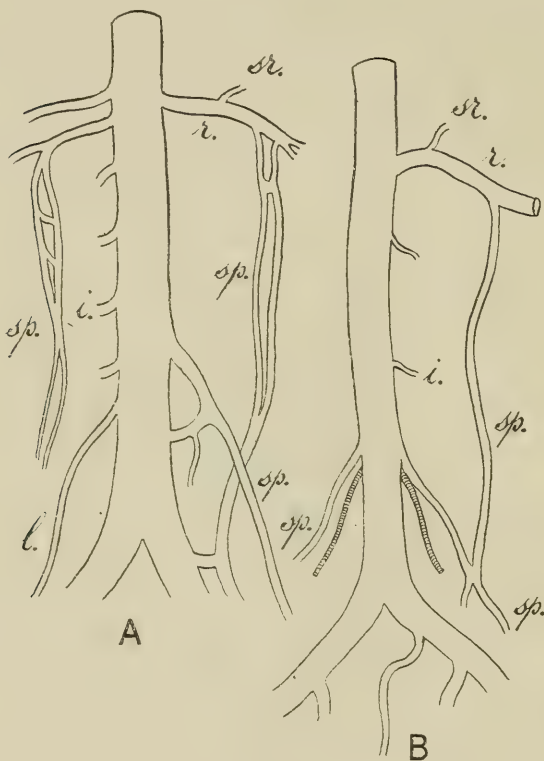
In *Macropus parryi* the typical Marsupial conditions are met with. The example which I dissected was in very good condition for the examination of the veins; for these vessels were turgid with blood and the smaller branches could be followed with ease. The renal veins are roughly symmetrical: there were two of them on the right side and one on the left; the left renal vein divided into three before entering the kidney. The ovarian and its parallel vessel, which empty themselves into the renal vein on either side, were well developed, and each couple of vessels were connected by more than one anastomosis. I am not quite certain whether they were also connected with the posterior ovarian veins flowing into the posterior part of the postcaval. In any case the connection must be by means of minor twigs; for the main vessels could be seen easily to pass dorsally to the posterior ovarian trunk on each side on their way from the generative organs. One of the two anterior ovarian veins becomes connected by a transverse branch with the common iliac vein just before the union of the latter with its fellow to form the postcaval.

The position of this vein, which runs transversely into the iliac, is very suggestive of the posterior lumbar parietal vein of other Mammals. It is, however, certain that in the present species the vein does not bring back blood from the parietes; it is merely a junction as already described. I could not find a vein corresponding to this on the right side. The left suprarenal vein had an antero-posterior course opening into the left renal. The two posterior ovarian veins were asymmetrical, the left joining the postcaval considerably higher up than the right. The left vein had furthermore two branches, also connecting it with the postcava lower down. The lowermost of these was a stout branch which gave off a backwardly running twig to the parietes; it may be that this vessel is really the homologue of the lumbar parietal above referred to. I noticed nothing of the kind in

connection with the right posterior ovarian vein. Between the right renal and the right posterior ovarian vein four median intercostal veins opened into the postcava. These veins appeared to me to be particularly slender.

In *Macropus hagenbecki* the renals were nearly symmetrical, and so also were the posterior spermatics; the anterior spermatic veins were present.

Text-fig. 134.



Postcaval vein and its branches in *Macropus parryi* (A) and *Macropus agilis* (B).

In the latter the spermatic arteries are shown emerging from the concealed aorta just below the posterior spermatic veins.

Lettering as in text-figs. 132, 133.

Macropus agilis agrees very closely with *M. parryi*. The left suprarenal flows into the left renal near to its entrance into the postcaval. The two vessels accompanying the ureter appeared to me to anastomose, one of them at any rate and that on the left side, with the posterior ovarian vein. The posterior ovarian veins

were symmetrical and had no secondary connections with the postcaval*. The intercostals were very slender as in *Macropus parryi* and apparently paired at their entrance into the postcaval. Into the left common iliac opened a medianly situate caudal vein. The ovarian arteries, contrary to what I have recorded in *Trichosurus fuliginosus*, emerged along with the ovarian veins. On the left side I counted two intercostal veins between the renal and the posterior ovarian.

Dasypus maugei (see text-fig. 133 A, p. 502) shows some slight variations in the postcaval branches, which do not, however, in any way detract from the quite typically Marsupial arrangement of the veins in that animal. I have examined most of these veins in five examples. The renal veins in all were symmetrical, the right being considerably in advance of the left. The posterior spermatic veins were also very nearly if not absolutely symmetrical. The usual two veins on each side entered the renals; but in one specimen at any rate the outermost of these veins seemed to enter the kidney itself, there being thus a kind of suggestion of a renal portal system. I have noticed this same connection with vessels actually within the kidney in other animals, and it may possibly be the persistence of an embryonic condition. The importance of these anterior spermatic veins appears to vary in individuals, and I think that they do not always anastomose with the posterior spermatics. The left suprarenal sometimes opens into the left renal and sometimes into the postcaval vein direct.

Among the *Edentata* I have chiefly examined the *Dasypodidae*. It is already clear from the investigations of Hochstetter that the genus *Dasypus* is characterised by a postrenally divided postcava. Two species figured and described by Hochstetter† (whose figures are copied by McClure‡), viz. *D. setosus* and *D. novemcinctus*, differ, however, in certain details. In *Dasypus setosus* the postcava is double at an earlier position than in the other species of *Dasypus*. Immediately after the embouchure of the two renal veins the postcava is divided in *D. setosus*. The division occurs lower down in *D. novemcinctus*. Moreover, in the former species another character of this genus is shown in a more marked fashion, i. e. the caudal vein forms a more complex rete of vessels. Finally, while in *D. setosus* only the left renal vein is double, both are double in *D. novemcinctus*. These peculiarities may of course be individual. In the generalities of the disposition of the veins concerned I can assert that *Dasypus vellerosus* resembles its congeners. There are, however, differences of detail which are worth noting, though some of them may of course be individual.

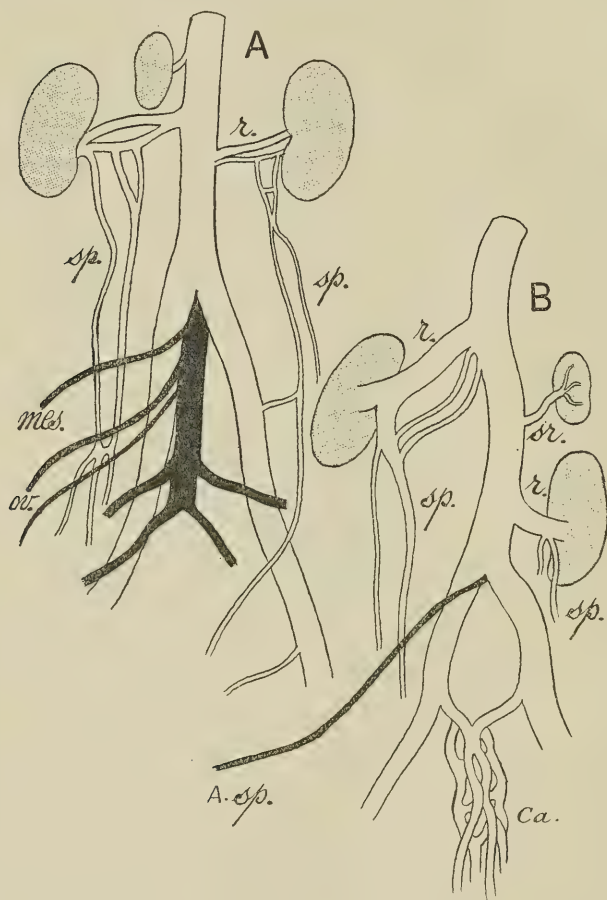
* It seems probable that the secondary connections described above in *Macropus parryi* are explicable on the same grounds as those urged in explaining the asymmetry in *Trichosurus fuliginosus*. The "connections" are probably to be looked upon as intercostal veins, and one of them (see text-fig. 134 A) has a branch to the parietes.

† Morph. Jahrb. t. c.

‡ Anat. Anz. xxix. 1906, p. 376, fig. 3, p. 377, fig. 4.

In *Dasypus vellerosus* (text-fig. 135 B) the renal veins are asymmetrical. The right arise in front of the left, as is so very usual among the Mammalia. On the right side there is one principal renal vein. This is reinforced by two others, but

Text-fig. 135.



Postcaval vein and its branches in *Tatusia peba* (A) and *Dasypus vellerosus* (B).

A.sp. Spermatic artery. Ca. Caudal plexus. mes. Mesenteric artery.
ov. Ovarian arteries.

Other lettering as in text-figs. 132, 133.

these latter rather slender trunks do not reach the kidney by a direct route. They open into the larger of the two veins which arise in common from the principal renal vein and descend

along the ureter. Their course is thus somewhat oblique. In this we have an exact resemblance to *D. novemcinctus*. On the left side the renal vein is quite single (it is double in both of the species already mentioned) and it gives off just before entering the kidney two veins like those of the opposite side of the body. The left suprarenal vein enters the postcaval, just anteriorly to the influx of the left renal. The point at which the postcaval bifurcates is behind the renal veins and seems to me to be pretty well intermediate in position as compared with the two forms studied by Hochstetter. The rete formed by the caudal vein is large, as in *Dasypus setosus*. It is a complex rete mixed up with the caudal artery in a way which I have not disentangled.

I have also had the opportunity of examining a fourth species of *Dasypus*, viz. *D. villosus*. Of this species I have dissected two examples, but am only able to say something concerning the details of the postcaval vein in one. Of the other I can only say that it showed the typical condition of this genus. It is of course important even to say this. For in some mammals which show a double postrenal postcaval (e. g. *Ictonyx**) there is variation, some examples being normally Eutherian without a postrenal doubling. In one example of *D. villosus* the veins in question were simpler than in the other types hitherto dealt with. The renals were asymmetrical as in the others; but there was only a single renal vein on each side. These two veins appeared to me to be of about the same size. The left suprarenal vein entered the left renal only just before its connection with the postcaval. From each renal arose a single ovarian vein descending parallel to the longitudinal axis of the body as in the other species. On both sides the lumbar veins were two, opening each into the divided region of the postcaval. I did not note these veins in the other species.

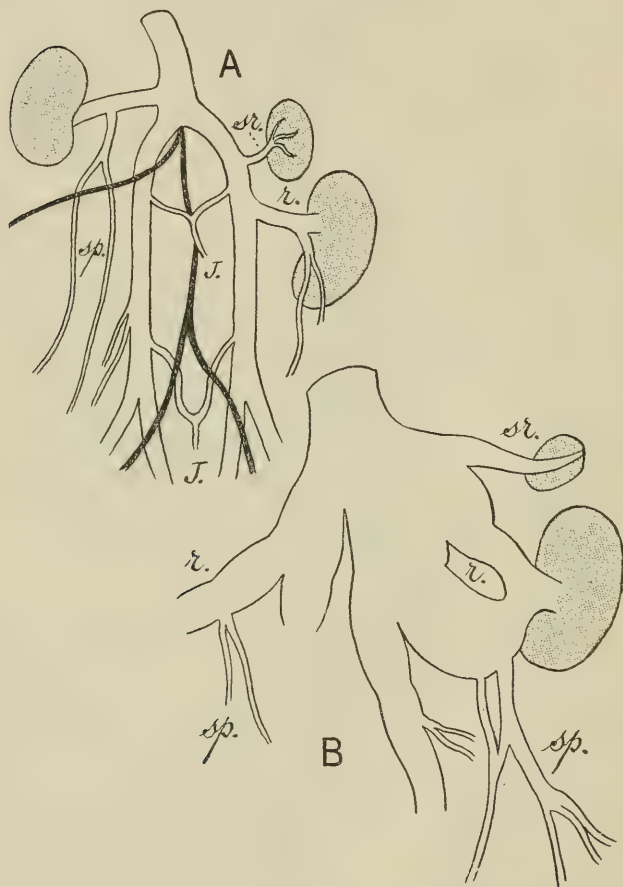
I am also able to add to what is known concerning the postcaval vein and its branches in the Armadillos some notes upon these veins in *Lysurus unicinctus*, a species of which I have dissected one example which was a male. In this Armadillo the division of the postcaval is more marked than in any species of *Dasypus* (among those referred to in the present communication). The division just extends anteriorly to the influx of the renal veins; and the conditions which obtain in this genus are therefore like those which occur in *Mephitis*† occasionally, where, however, it is only one renal (the left) that opens into the divided portion of the postcaval. In the Armadillo with which I am now concerned both renal veins are thus separate from each other. Another noteworthy point about this species is the greater calibre of the renal vessels on the left side of the body as compared with those of the right. They were vast in the specimen which I dissected and turgid with blood. On the left side of the body

* Cf. Beddard on *Galidia* &c., P. Z. S. 1909, p. 491.

† P. Z. S. 1909, p. 492.

there are in fact two renals, of which the lower is the larger; the two join before entering the substance of the kidney and may be also said to rejoin before entering the left half of the postcaval vein. The diameter of the lower renal is greater than that of the postcaval into which it flows. The left suprarenal vessel just

Text-fig. 136.



Postcaval vein and its branches in *Centetes ecaudatus* (A) and
Lysiuurus uncinatus (B).

J. Junction between two postcavae in *Centetes*.

joins the upper renal vein before the latter joins its fellows. From the lower renal vein two veins arise, of which the outer is the spermatic; it soon divides into two trunks, but just before this

sends off a branch to the inner vessel which runs along the ureter. On the right side the renal vein was quite single. With it are connected two veins as on the opposite side; but these as well as the renal vein were of less calibre than their fellows on the left. I noticed a double lumbar parietal vein on the left side; but have no notes concerning a corresponding vein on the right. I also observed a caudal plexus in the pelvic region, which is so characteristic a feature of the venous system of the genus *Dasypus*. In the large tract of postcaval, which is double, it is clear that this species comes nearer to *Dasypus setosus* than to the other species of that genus which have been described.

I did not find posterior spermatic veins in this Armadillo, and am sure that I have not confused such veins with the lumbar parietal veins already referred to.

I have already mentioned in a preliminary note* that the venous system of the genus *Tatusia* is constructed upon the same plan as that of the genus *Dasypus*, instancing the species *Tatusia kappleri*. Of that species I have accurate notes upon the left side of the body only. The postcava is double at some little distance behind the influx of the renal veins and just in front of the origin of the ovarian arteries. The left renal vein is single and enters the postcaval behind and not in common with the supra-renal of its side. Just before the renal vein reaches the kidney, or, to speak more accurately, just after it has left the kidney, it gives off a descending branch which fuses with the ovarian vein to be described shortly and then bifurcates, one branch going to the ovary and the other passing down the ureter. The latter is connected with an ascending branch which I did not trace so far forwards as the renal vein, but it evidently corresponds to the second of two veins which debouch into the renal vein in other Armadillos. The ovarian veins are quite symmetrical, and, as in *Dasypus novemcinctus*, as figured by Hochstetter, flow into each half of the postcava just after the bifurcation and on a level with the emergence of the posterior mesenteric artery.

Of *Tatusia peba* I have more elaborate notes. The individual which I dissected shows some differences from the specimen of *Tatusia kappleri* just described. The renal veins (see text-fig. 135 A, p. 506) are asymmetrical, but the left does not become connected with the postcaval a very long way below the right. The renal veins are not, however, single on each side as in *Tatusia kappleri* (? as to right side); there are two veins on each side, of which the more anterior is in both cases the larger. From the lower of the two renal veins of each side depend two veins which are again fairly symmetrical on both sides of the body. These are shown in the figure (text-fig. 135 A), and they will be seen to join and rejoin in a plexus-like fashion. The outer branch is ovarian and the two inner follow the ureter. I do not think that there are ovarian veins connected with these and with

* Amer. Journ. Anat. 1907, p. 111.

the main postcaval trunk. On one side I found a small vein which I regard as lumbar; but I could see nothing on the other side. On the other hand, an additional vein to the ovary was connected with the postcavals far down and in the pelvic region close to the ovaries. The postcaval becomes a double vein some way after the renals and the position of the point of bifurcation seems to be much as in *Tatusia kappleri*. I have no notes as to a caudal plexus in this Armadillo, and I do not think that I should have failed to note it were the plexus present. At the same time I feel unable to assert positively that it is absent.

It is clear, therefore, from what has been said and from a comparison of the facts which I am able to bring forward here with those noted by other observers, that the Armadillos as a family are to be characterised by the invariable presence of a divided postcaval, but the actual point at which the division occurs differs. Again, in all Armadillos the sexual veins are symmetrical and connected with the renals, while accessory veins to the gonads are not invariably present; when present they occur some way down the postcava and are symmetrical. The caudal plexus is not universal, but is characteristic of the genus *Dasyppus* alone of those examined.

While it appears to be clear, from the investigations of Hyrtl*, Hochstetter†, and myself‡, that the divided postcaval vein is a distinctive feature of the Armadillos, occurring, without exceptions as to species or individuals, in all of the four genera which are at the present time known, the facts are otherwise among the **Insectivora**. In both *Erinaceus algirus* and *E. europæus* there is a single postcaval vein which is undivided until it divides in the usual way to form the two iliac arteries, or there may be (*E. europæus*) a divided postcaval as in *Centetes*. On the other hand, in the genus *Centetes* the postcaval vein is broadly as in the Armadillos, though, as will be seen presently, there are differences. In *Erinaceus algirus*—to commence with the simpler form seen in Insectivora—the renals are asymmetrical, the left lying, as is the rule in such cases, below the right vein. The left suprarenal vein opens into the left renal and just above the entry into the latter vein of the ovarian vein which runs down along the ureter. The corresponding ovarian vein of the right side enters the postcaval at a point about on a level with the entrance of the left renal: there is thus a kind of symmetry in the ovarian veins such as occurs in other animals, for instance in *Lagostomus trichodactylus*§, *Paradoxurus hermaphroditus*||, &c. The two lumbar parietal veins, so constant among mammals, open symmetrically into the iliac veins just below the partition of the postcaval.

In an example of *Erinaceus europæus* I observed a slight difference from the state of affairs here recorded in *E. algirus*, which I do not for a moment attribute to specific differences, but

* Denkschr. Ak. Wien, 1855.

† Morph. Jahrb. xx.

‡ *Suprà*.

§ *Vide* p. 516 of the present communication.

|| Beddard on *Galidia* &c., P. Z. S. 1909, p. 489.

rather regard as a mere variation of an individual character. In the European Hedgehog I found that the renal veins were quite or very nearly symmetrical. It ought also to be stated that the postcaval vein lay posteriorly to the right of the aorta, as is the normal position in Eutherian Mammals. In a second specimen there was a divided postcaval as in *Centetes*; but I am unable to give details.

In *Centetes ecaudatus* (see text-fig. 136 A, p. 508) I found the conditions characteristic of the Armadillos somewhat exaggerated. In a specimen of that Insectivore which I dissected some two years ago the postcaval was formed of two parallel vessels from a point slightly in front of the influx of both renal veins anteriorly. A larger region was therefore double that in *Dasypus* &c. The renal veins were single on both sides, the complication of these veins so often seen among the Armadillos being in *Centetes* quite undeveloped. The two divisions of the postcaval after the influx of the renal veins were separated somewhat widely as in *Dasypus* &c.; but this separation was not complete. For two veins bridged over the intervening space, as is shown in the figure (text-fig. 136 A). The first of these was slightly behind the left renal, and each slender vein joined its fellow to form a short backwardly running median vein. Further back still, just in front of the iliac veins, there was another small median vein formed by the union of two similar branches. The posterior mesenteric artery emerges from the aorta in front of the anterior bridge. The conditions thus shown are not seen in the Armadillos. But they exactly correspond (in that there are two bridges between the right and left postcavæ) to a stage in the development of these veins in *Echidna* figured by Hochstetter*, whose figures have been copied by McClure†.

Such anastomoses also occur in *Didelphys* as stated by McClure. It is perhaps, therefore, possible to say that the presence of such anastomoses uniting the postrenal section of the postcaval, which is, as I presume, formed at least more anteriorly by the two sub-cardinals of the embryo, is an archaic character; for during the development of *Didelphys* such anastomoses occur of which there are in that Marsupial, as already stated, frequent traces in the adult in various positions and of differing degree, many of which have been described and figured by McClure in his paper to which reference has been made so often in the present communication. But without actual developmental facts relating to *Centetes* it is of course dangerous to press any such comparisons very far. For it is equally possible that the anastomoses in question are a remnant of the cardinal collateral system. In *Centetes*, as in *Erinaceus* and other primitive mammals, each renal vein received from the hinder region of the body two veins which course along the ureter; one of these, as in other animals is the ovarian vein.

* "Monotremen u. Marsupialier," in Semon's Zool. Forschungsreise in Australien, Bd. ii. Lief. iii.

† Amer. Journ. Anat. ii. 1903, p. 400, fig. x.

The lumbar parietal vein of one side at any rate emerged from the parietes in a plexus form and entered the right half of the postcaval some distance below the entrance of the renal of the opposite side of the body and *a fortiori* below the entrance of the renal of its own side of the body. The left suprarenal vein is formed of three principal twigs which leave the suprarenal body; it enters the postcaval in front of the entrance of the left renal and not in common with that vein. It is therefore to be noted that in this animal the suprarenal and ovarian veins do not lie in the same straight line and present the appearance of being portions of the same original vein (the left posterior cardinal) as they do in various Marsupials. Although I am of my own knowledge unable to do more than state that one of the two examples of *Erinaceus europæus* which I dissected showed the divided postcaval characteristic of the Edentates, Monotremes, &c., the conditions which actually obtain in such a specimen with a divided postcaval have been figured and described by Hochstetter*.

This figure shows that the arrangement of the veins in *Erinaceus* is in some respects different from that which I have described and here figure in *Centetes* (see text-fig. 136 A, p. 508). They both agree, however, in that the division of the postcaval extends further forward than in the Armadillos. The postcaval is formed of two veins in both species up to a point just anterior to the opening into it of the right (and anterior) of the two renals. There appears, moreover, to be a junction between the two halves of the postcaval in *Erinaceus* corresponding to the posterior of the two transverse trunks of *Centetes*. Otherwise one is struck rather by the differences than by the points of likeness which the postcaval venous systems in these two types show to each other. The kidneys and their veins are more symmetrical in *Erinaceus*. From the left renal arises only a single vein, which is the ovarian of *Centetes*. It is unaccompanied in *Erinaceus* by a second vein coursing along the ureter. Moreover, this vein in *Erinaceus* anastomoses with a posterior ovarian vein as in the genus *Dasyurus* (in some specimens). The condition is, in fact, more "Marsupial" than is that of *Centetes*. On the right side there is no symmetry in the ovarian vein. It flows into the postcaval vein of its side, and not into the renal as in *Centetes*. It, however, joins the other ovarian vein below. It is to be noted that this example of *Erinaceus*, which Hochstetter speaks of as "abnormal" in the disposition of the postcaval vein, agrees in this last particular with a specimen of *Erinaceus algirus* examined by myself and reported upon in the present communication. For in the latter example the ovarian veins show precisely the same asymmetry. It is clear from the additional facts which I am able to bring forward in this paper, that the postcaval venous system of the Insectivora has not so completely rid itself of its primitive paired character as it has in the Carnivora, where apparently only vestiges

* Morph. Jahrb. Bd. xx. 1893, Taf. xxiii. fig. 24.

remain of the double postcaval*. The Edentata, Insectivora, and Carnivora can be arranged in a series in the order in which they have just been named in respect of the double character of the postcaval veins, *i. e.* the more or less complete persistence of both of the subcardinal veins or cardinal collateral veins. It is doubtless important to note that the Rodentia, which are equally primitive in the azygos veins, show no traces of any likeness to the Insectivora in respect of the postcaval.

The condition characterising the adult *Centetes* and *Dasypodidae* is also very well seen as a temporary feature of the foetal Mole. At a certain stage figured by Messrs. Soulié and Bonne†, there are two thick veins which unite inferiorly and which I presume represent the cardinal collaterals as described by McClure. A small branch of the renals which is not lettered by these authors seems to correspond to the real cardinals. Between the preserved cardinal collaterals (in the 12.5 mm. long embryo described by Soulié and Bonne), which are thick veins, is a medianly situated single vein of some calibre, which may perhaps be the equivalent of the subcardinals as described by McClure in the American Opossum, or possibly be the equivalent of the median prolongations of the commissural vessels in *Centetes*. This soon disappears as an important vessel, but remains as a slight commissure. The authors speak of the persistent postcaval as being formed in the postrenal region by the "right internal vein of mesonephros," which is not homologised with any particular division of cardinals. There seems also at a certain stage to be a caudal plexus which heightens the likeness to the adult Armadillo. The developmental phenomena argue at least a general similarity with other Mammals as described by other authors.

As to the *Ungulata*, I have examined the postcaval and its branches in several examples of *Hyrax capensis* and in one of *H. dorsalis*. The general arrangement in both species appears to be as follows:—The renals are asymmetrical as usual, the right opening into the postcaval above the left. The postcaval postrenally lies as usual to the right of the aorta. The ovarian vein on the left side opens into the renal, but on the right into the postcaval in line with the orifice of the left renal. There is thus a kind of symmetry between the two ovarian veins such as is met with in the Rodents, some Carnivores, &c. In one specimen (of *capensis*) I noted more particularly the branches of the right ovarian vein. This vein shortly after leaving the postcaval (it is simpler for purposes of description to disregard the direction of the blood-flow and to treat these affluents as branches) divided into two equisized veins. The anterior of these was directed forwards and ran along the body-wall giving off branches to the parietes. It ran about parallel to the postcaval and its course suggests an anterior section of the postcardinal. The

* See Beddard, P. Z. S. 1909, p. 491, text-fig. 131.

† "Recherches sur le développement du système veineux chez la taupe," Journ. de l'Anat. et Phys. xli. 1905, p. 1.

posterior branch ran in the same straight line as the anterior branch and divided into two principal trunks, of which the anterior supplies the ovary itself and the hinder the oviduct. In two other examples I found this branch just as plain. It is remarkable that it was at least not so obvious on the left side; indeed I made no notes at all as to its occurrence on that side of the body. It is possible that the restriction to, or at least the more marked development upon, the right side of the body is connected with the persistence of the right azygos vein only (as a rule) in this Subungulate.

McClure has discovered * the interesting fact that in *Tragulus meminna* the postcaval is divided postrenally as in Armadillos &c., and I have been able to confirm † him by the examination of three individuals. Since the publication of my note referred to I have examined two other examples of *Tragulus meminna* which presented an identical disposition of the vena cava posterior. Furthermore, I have still more recently dissected an example of *Tragulus stanleyanus* in which the same bifurcation of the postcaval occurred, and in the same way the genital veins arose symmetrically from the region of the postcaval.

The **Lemuroidea**.—In the course of some notes upon the anatomy of *Chiromys madagascariensis* ‡ I have pointed out that within the group of Lemurs considerable variations exist in the tributaries of the postcaval vein. It seems to me to be evident—though I did not point it out in the memoir to which I have referred—that *Microcebus* has retained the Marsupial and Edentate character in its venous system, in that the spermatic veins arose more or less symmetrically some way down the postcaval and that both were connected with the renal veins by a slender vessel on each side, which seems to me to represent the anterior spermatic vein of Marsupials, but in this Lemur (*Microcebus*) in the course of disappearance. On the other hand, in *Chiromys* (of which Lemur I reported upon two examples in the paper referred to and have here to report upon a third §) only the posterior spermatic veins in the male at any rate are left.

A study of the postcaval and its branches in *Lemur catta* shows that this region of the venous system is like that of *Microcebus*. The two renals are single on both sides, but asymmetrical in the usual way. Into each renal flows on the posterior side an anterior parietal vessel, which corresponds, as I believe, to one of the two veins on each side which accompany the ureter in the Marsupials. On the left side there was also a small vein like that in *Microcebus* closely accompanying the postcaval and flowing into it above close to its junction with the left renal. Posteriorly, I think, but am not quite certain, it joins the spermatic of its side. In this case the likeness to *Microcebus* is quite close. The two principal and

* "The Postcava of an Adult Indian Chevrotain," Anat. Anz. xxix. 1906, p. 375.

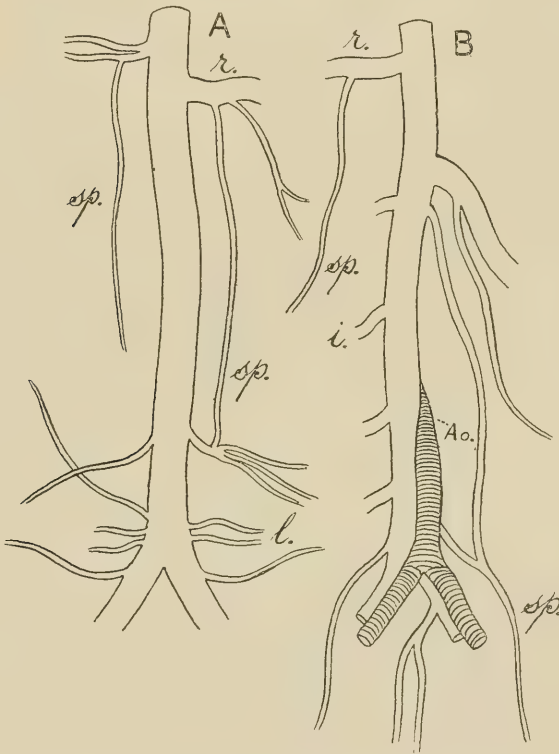
† Amer. Journ. Anat. vol. vii. 1907, p. 111.

‡ P. Z. S. 1908, p. 694.

§ Vide *infra*, p. 521.

posterior spermatic veins flow into the postcava quite far back near to the bifurcation of that vein. They are quite symmetrical. Between the influx of the left renal above and of the spermatic veins below I counted four unpaired intercostal trunks. The iliac veins were asymmetrical, as is shown in the drawing (text-fig. 137), the internal arising as one trunk from the left external iliac.

Text-fig. 137.

Postcaval vein and its branches in *Microcebus smithii* (A) and *Lemur catta* (B).

Ao. Aorta. Other lettering as in text-figs. 132, 133.

In so far as concerns the **Rodentia**, the Rabbit is naturally very well known *; and Hochstetter has furthermore called attention † to several variations in the venous system as affecting the tributaries of the postcaval. On the whole, it would appear that the

* Krause, 'Anatomie des Kaninchens,' Leipsic, 1884; Haswell & Parker, 'Text-book of Zoology,' London; and many similar works.

† Morph. Jahrb. Bd. xx. pp. 585, 586, figs. 7, 8, 9.

several branches of the postcava in that animal are as in the Hystriiform Rodents, of which I give a certain number of details presently. In two out of the three venous systems figured by Hochstetter the left spermatic vein entered the left renal vein, while the right spermatic vein entered the postcaval a good way below the entrance into it of the two renals. A very remarkable state of affairs was shown in a third example which I have not been able to parallel in any Rodent dissected by myself. In this animal the left spermatic artery entered the left parietal lumbar vein.

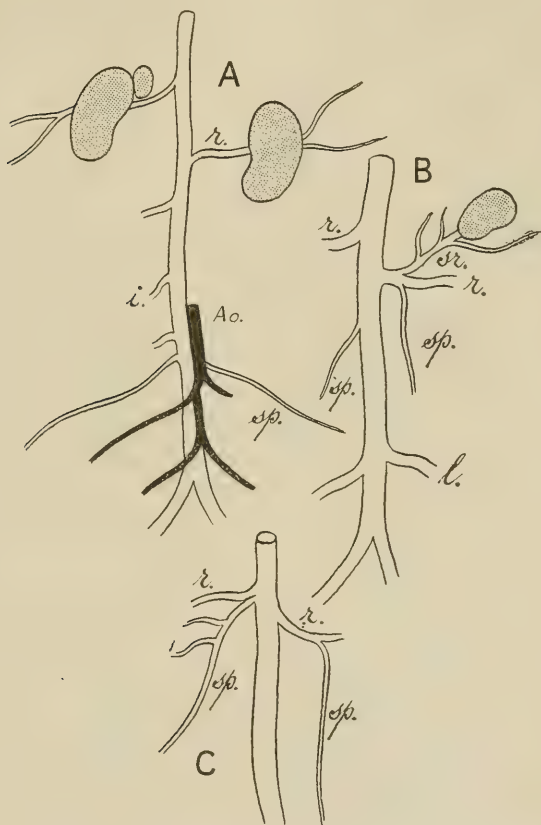
Of *Hystrix cristata* I have examined the postcaval vein and its branches in three examples, in all of which the conditions were much the same but not precisely identical. All the renal veins showed the usual asymmetry, which need not be further particularised. In all, the left ovarian vein entered the left renal vein; in two of the individuals the right ovarian vein entered the postcaval a good way below the entrance of the left renal; in the remaining specimen the point of entrance was higher up on a level with the entrance of the left renal, as in the *Myomorpha* generally. In one specimen (I have no notes upon the other two as concerns this vein) I observed the right lumbar parietal vein to enter the corresponding iliac vein and not the main trunk of the postcaval. In another specimen (again I have no notes upon the matter in the remaining two) the caudal vein was asymmetrical and entered the left iliac.

Chinchilla lanigera is quite like *Hystrix cristata*; in both of two specimens the renals were asymmetrical and the left genital vein entered the left renal, while the right genital vein entered the postcava some way down. An example of *Dasyprocta cristata* showed the same features. A specimen of the Capybara, *Hydrocherus capybara*, was identical, save for the fact that the renal veins were fairly symmetrical. The left suprarenal vein, it should be mentioned, opened directly into the postcaval vein above the renals. In a second specimen of this Rodent the renal veins were also symmetrical. A specimen of *Aulacodus swindernianus* showed also symmetrical renal veins; the ovarian veins were as in the last three genera. Of the Viscacha, *Lagostomus trichodactylus*, I have dissected the postcava in two specimens. In one the renal veins were about symmetrical; in the other the right was a little in advance of the left. In both specimens the ovarian vein of the left side opened into the corresponding renal, and of the other side into the postcava opposite to the left renal.

The postcaval and its branches in *Hydromys chrysogaster* (text-fig. 138 B) are as follows:—The postcaval itself occupies the usual position to the right of the aorta. The renals are asymmetrical, the left vein opening below the right in position. The left suprarenal vein receives, after leaving the suprarenal body, three parietal veins, two anteriorly and one posteriorly. The left ovarian vein enters the left renal, and the right ovarian vein enters the main trunk of the postcaval not a very great way

behind the entrance of the left renal, the prevailing Eutherian arrangement thus occurring. The lumbar veins are asymmetrical, the left vein debouching into the postcaval above the right.

Text-fig. 138.



Postcaval vein and its branches in *Sciurus prevesti* (A), *Hydromys chrysogaster* (B), and *Dipus hirtipes* (C).

Lettering as in text-figs. 132, 133, 137.

Gerbillus ægyptius and *Zapus hudsonianus* (text-fig. 139, A, B, p. 519), which are both members of the group Myomorpha, but which are placed by Mr. Thomas* in quite different sections of that group, show an interesting point of similarity, of which possibly it is easy to exaggerate the importance as a mark of similarity. Posteriorly in both animals the postcaval vein lies accurately above the aorta

* P. Z. S. 1896, p. 1016.

(i. e. "below" when the animal is dissected, as is usual, from the ventral surface) for some distance in front of the point where it emerges from between the divergent iliac arteries accurately in the middle line. This is, of course, only an exaggeration of the prevailing Eutherian condition. Still it is noteworthy that a new kind of symmetry in the relation of vein and artery precisely the reverse of that characteristic of the Marsupials should be visible in these Murines. Finally, in both of these species the spermatic vein entered the iliac vein of its side, and was thus not directly connected with the postcaval or renal, as is the usual state of affairs in Eutherian Mammals.

In *Georhynchus capensis* (text-fig. 139 C) the veins with which I am concerned in the present communication are different from those of some other Rodents. The renal veins are not situated opposite to each other, the left being below the right. The right ovarian vein is symmetrical with the left renal and passes, like it, almost at right angles to the postcava, the ovary of that side being situated to the outside of and not much behind the kidney. It gives off two branches which run at right angles to it and parallel with the postcava along the ureter and the oviduct. On the left side the ovarian vein joins the left renal, but before it joins receives a vessel running along the oviduct. The renal vein nearer to its embouchure into the postcaval receives a slender vein which runs along the ureter. Posteriorly there is a caudal vein which opens into the left of the two iliac veins which together form the postcaval. *Dipus hirtipes* (text-fig. 138 C, p. 517) does not differ much from *Georhynchus*. But the right ovarian vein flows into the postcaval rather nearer to the right renal.

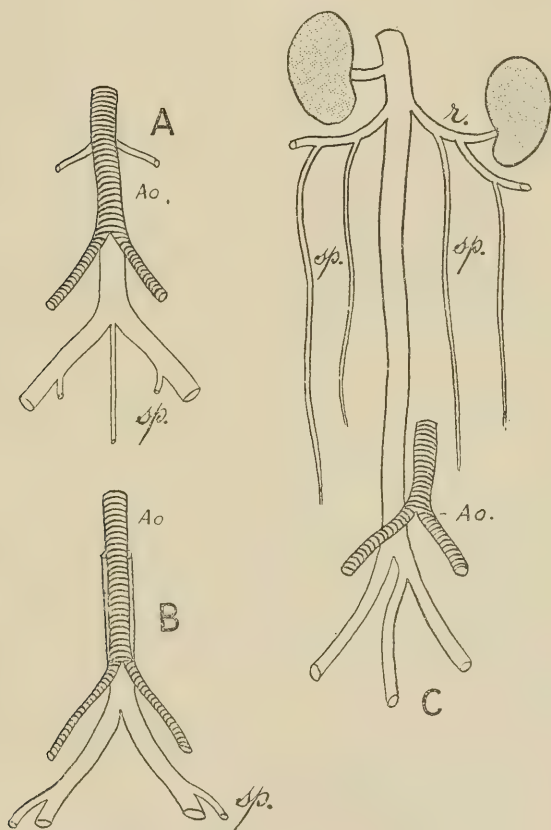
Graphiurus murinus is, in many respects, like *Georhynchus capensis*. The renals are even more asymmetrical, the space of postcava left between their respective mouths being greater. The left suprarenal vein enters the postcava opposite to the right renal. Between the two renals enters the right ovarian vein; this is, as in *Georhynchus*, at right angles or nearly so to the postcaval stem, and, as in the Rodent mentioned, receives an ascending vein which runs along the oviduct. On the left side of the body the ovarian vein enters the left renal; but the latter vein, instead of being at right angles with the postcava or sloping posteriorly, is directed rather anteriorly. This ovarian vein receives an ascending branch as does the right ovarian vein.

In *Sciurus prevosti* (text-fig. 138 A) the renal veins were asymmetrical in the usual fashion. The ovarian veins were symmetrical and situated far back, flowing into the postcaval not far in front of the union of the iliacs. Between these veins and the left renal there were three unpaired intercostal veins. *Sciurus cinereus* was the same, except that the two spermatic veins appeared to open into the postcava by a common stem. In front of this were two lumbar parietal veins, of which the left-hand one was rather the anterior. In *Sciurus maximus* the spermatic veins had the same symmetry and posterior origin.

The posteriorly situated point of opening of the spermatic and ovarian veins in the genus *Sciurus* is, so to speak, a less exaggerated condition of these veins than that found in *Gerbillus* and *Zapus*, and is suggestive of the condition which appears to be universal among the Marsupials.

In *Notiomys cervinus* (of which I have dissected two examples, both females) the renal veins show the usual asymmetry, the

Text-fig. 139.



Postcaval vein and its branches in *Zapus hudsonianus* (A), *Gerbillus aegyptius* (B), and *Georhynchus capensis* (C).

Lettering as in text-figs. 132, 133, 137.

right entering the postcava higher up than the left. In both specimens the right ovarian vein entered the postcaval at a point pretty well opposite to the entrance of the left renal. The left

ovarian vein, on the other hand, entered the left renal. In one of the two examples which I dissected, and of which I took more elaborate notes, a small vessel running along the ureter also entered the left renal. In this specimen the left suprarenal vein before entering the left renal received a branch from the parietes anteriorly, and there were two large lumbar parietal veins entering the postcava before its posterior bifurcation and asymmetrically; the left vein entered the postcava higher up than the right. Although these vessels ran towards the uterus, they did not, as it appeared to me, receive any affluents from any part of the generative system.

In *Mus coucha* the conditions which obtain are very much like those seen in *Notiomys*. The two renals are asymmetrical in the same way and the ovarian veins have precisely the same connections, which, on account of their identity, I need not recapitulate. There are two other veins which correspond in their distribution to the lumbar parietal veins of *Notiomys*, but which are differently connected with the postcaval. On the left side of the body the vein in question enters the left renal to the inside of the point of entrance of the left ovarian vein, but quite independently of it. On the right side of the body this parietal vein has quite a different connection, for it joins the right ovarian vein before the latter debouches into the postcaval vein opposite to the entrance of the left renal.

Otomys irroratus agrees with *Notiomys cervinus* in the disposition of the postcaval and its branches. The two renals are asymmetrical, the left, as usual, being below the right. Into the left renal flows a vein which is composed of two chief affluents, a vein from the ovary itself and a longer vein from the uterus. On the right side the same two veins are present, and form a common trunk which flows into the postcava just opposite to the entrance of the left renal. The two suprarenal veins enter the postcaval independently of the renals. The left suprarenal has a curious course; it actually pierces the liver on its way to join the postcaval. Below the ovarian veins a large lumbar parietal vein on each side joins the postcaval. These are nearly if not quite symmetrical.

In *Arvicanthus pumilus* there are no great differences. The renals are not symmetrical; the left is joined by the ovarian vein, while the right ovarian vein enters the postcaval a little way below the entrance of the left renal.

The few Rodents upon which I am able to report in the present communication very clearly show that this group is by no means so uniform as the American Edentates or Marsupials. It is furthermore plain that the Hystricomorpha present uniform characters in the postcaval vein and its branches. There are no differences of importance among the six genera belonging to this group which I have examined.

The Myomorpha, on the other hand, are by no means so uniform. *Hydromys* is like the Hystricomorpha; *Mus*, *Notiomys*,

Georychus, and some other genera agree closely, while *Zapus* and *Gerbillus* seem to approximate to the Squirrels. Opinions as to the classification of Rodents vary greatly*.

§ *Some Variations of the Postcaval Trunk.*

Under this heading should no doubt strictly be included a very large proportion of the facts with which I deal in the present communication. I limit myself, however, in this section to two cases of apparently abnormal position of the postcava; "abnormal" because they are not like any condition of that vein which is characteristic of a given group or even minor subdivision of any mammalian order. From this point of view, therefore, I cannot include the occasional duplication of the postcaval in *Erinaceus*, since it would appear to be fairly common in that genus, and is also a marked character of the Edentata, &c. Moreover, it might be urged that the single postcaval lying to the right of the aorta is the abnormal condition in *Erinaceus europæus*.

In an example of *Chiromys madagascariensis* dissected in September of last year I found that postrenally the postcaval vein lay to the left instead of to the right of the aorta. The normal condition of this vein has been already and quite recently described by myself†. The arrangement of the spermatic or ovarian veins as the case may be appeared to me to differ in the two sexes, and did undoubtedly differ in the two individuals upon which I reported to the Society. In both individuals the right spermatic or ovarian vein flowed into the postcava rather distally but still some way in front of the posterior bifurcation of that vein. In the female the left ovarian flowed into the left renal, while in the male the corresponding spermatic vein flowed into the postcaval a little way anterior to the entrance of the right spermatic vein. The relative position of these veins in the male is important to be borne in mind. In the abnormal example of *Chiromys* to which I refer in the present communication, the relative position of the two spermatic veins was—in correspondence, as I imagine, with the sinistral postcava—entirely reversed. The right spermatic vein entered the postcava anteriorly to the left.

There was, however, no reversion in the position of the renal veins; they lay exactly as in the two normal examples described by myself. It may be worth while mentioning that in this abnormally veined *Chiromys* the small anterior lumbar parietal vein, to which I directed attention as occupying in the male the position of the ovarian vein in the female, is present; it lies, however, on the opposite side of the renal and therefore ends anteriorly; it is not to be confused with a suprarenal vein. This variation in *Chiromys madagascariensis* seems to be exactly paralleled in a variation of *Homo sapiens* referred to by

* Cf., e.g., Thomas, P. Z. S. 1896, and Tullberg, Nov. Act. Upsala, 1899.

† P. Z. S. 1908, p. 700.

Hochstetter*, where a prevailing left posterior vena cava was accompanied by a right spermatic vein opening into the right renal vein and a left spermatic opening into the postcava itself. This is the exact reverse of the normal conditions obtaining in Man, where, as in so many animals, it is the left genital vein which pours its blood into the left renal while the right-hand vein enters the postcava directly.

I have only examined one example of the American Monkey *Chrysothrix sciureus*, and it is rather remarkable to find that that one specimen, not in any way selected, should show a variation; for so I must in the present state of our knowledge interpret the conditions shown by the postrenal section of the postcaval vein. The vein was in fact, as in *Chiromys* just dealt with, developed on the left side instead of the right. It lay very distinctly to the left of the aorta. Corresponding with this abnormality in the position of the postcaval, its principal branches showed an entirely similar position to those of *Chiromys* and the human abnormality which I have compared with it. For of the two ovarian veins the left entered the main trunk of the postcaval some little way down the latter, while the right ovarian vein poured its contents in the postcaval just below the entrance of the right renal vein. I cannot but think that in the normal arrangement of the veins of this animal the postcaval was on the right side of the aorta and the position of the two ovarian veins was reversed, the left being anterior to the right.

§ *Résumé and General Considerations.*

It is, in the first place, clear from what has been detailed in the foregoing pages, and from my previous papers in which the postcaval system is dealt with, that the postcaval system of veins in Mammals is subject to variations of an individual character. This conclusion is not of course deduced from my own work only, but from what has been written by others which I am able to confirm for other animals and from additional examples of species already known. Even in the very few individuals of certain species which I have been able to dissect, variation has always been noticeable. For instance, in three specimens of *Chiromys* variations occur; in four examples of *Ictonyx capensis*, in three of *Hystrix cristata*, in two specimens of *Erinaceus europæus*, in two of *Suricata tetradactyla*, in three examples of *Dasyurus maculatus*. And these variations together nearly cover the range of variation which the postcaval and its branches show among the Mammalia. In spite, however, of these variations from individual to individual of a given species, there are certain characteristics of groups which may be laid down with some confidence, and with more confidence—I venture to assert—from a consideration of the new facts which I bring forward here.

* *Loc. cit.* p. 638. This paper contains a good many references to the literature of venous abnormalities in man, as well as descriptions of instances.

Thus the Marsupials possess a general character of the postcaval and its branches which is shared by no other group of mammals. Furthermore, it is very noteworthy that within this particular group the variations in important matters is but slight. Thus the only features which differ at all from genus to genus or from species to species are the symmetry or asymmetry of the renals, the exact origin of the suprarenal vein of the left side, whether from the left renal or from an adjacent part of the postcaval, and the freedom or connection by anastomoses of the anterior pair of veins which leave the renals on each side together, and finally their connection or perhaps non-connection by anastomoses with the posterior spermatic veins where they cross them dorsally on their way to the testes or ovaries. It will have been observed that it is quite impossible to distinguish the Carnivorous from the Diprotodont Marsupials by their veins; the whole group of the Marsupials forms an assemblage of which the various members are closely connected in these characters.

So far as facts already known enable us to say, it seems clear that of the Marsupials only an individual of *Trichosurus vulpecula* and the genus *Didelphys*, and in the latter only occasionally and by no means typically, have preserved the earlier condition of the mammalian postcaval system as seen in *Ornithorhynchus* and in *Echidna*, where the postrenal part of that vein is persistently double, being developed out of both collateral veins of the embryo*. This condition is, however, fully characteristic of the Edentata, which form an assemblage apparently quite as distinct in these characters as are the Marsupials. The present communication to the Society allows me to confirm the data of Hochstetter and Hyrtl by fresh examples of species of Dasypodidae. I may also mention that in two examples of *Myrmecophaga jubata* which I have recently dissected the postcaval vein was double postrenally, though I have not made notes of sufficient elaborateness to permit of a detailed account of the facts in the earlier part of this paper. Hochstetter has also stated that *Myrmecophaga* and both of the Sloths†, viz. *Choloepus didactylus* and *Bradypus tridactylus*, possess the same type of postcaval system, and also the Old World Edentate, *Manis*‡. Judged by the conditions which obtain in the Monotremata, the Edentata are more primitive than are the Marsupials. And, moreover, no Edentate, so far as is known at present, shows the typical Eutherian condition of the veins in question. It is a very singular fact that among the Marsupials the typical Eutherian condition of the postcaval is seen in only one form (*Petaurus tanguanoides*)§, just as the Eutherian placenta is also seen in only one form. We know so little about the Insectivora as regards their venous

* Morph. Jahrb. xx. p. 362, pl. xv., and in Amer. Journ. Anat. ii. pl. iv. figs. 17, 21, &c.

† Morph. Jahrb. xxv. p. 621.

‡ Hyrtl, Denkschr. Ak. Wien, vi. 1854.

§ Morph. Jahrb. xx. pl. xxiii. fig. 26. And, according to McClure, in one example of *Phalanger ursinus*. This of course may be an abnormality.

system that it is rather premature at present to attempt to lay down any statement of general application. But such facts as we have distinctly prove that the Insectivora occupy a somewhat midway position. They are at least commencing to lose the double postrenal caval. Still it is very frequent. Whether Hochstetter's discovery of a similarly divided postcaval in *Pteropus* * will prove this condition to be characteristic of the Bats—or at least the Fruit-Bats—remains to be seen, as also whether the Cetacea are largely or mostly thus to be characterised. It can be safely said that the Carnivora † only show remnants of this state of affairs; but such rudiments are not without significance inasmuch as they occur among the Arctoidea, which are perhaps to be regarded as the most primitive among the Carnivora. McClure's interesting discovery, confirmed by myself, of the condition of the postcaval in the Ungulate *Tragulus* adds one Ungulate genus to this same category; but as this group has been but little studied from the present point of view, it would be premature to base any arguments upon the facts. In contradistinction to the groups of mammals already considered, we have the Rodentia, Lemuroidea, and Primates, which invariably show a postcaval vein lying to the right of the aorta postrenally and possessing no fellow upon the opposite side. That variations have been described does not alter the fact that these Eutherian mammals differ from the Eutherian groups already dealt with. It is true that here again the actual facts known require much increase before any generalisations can certainly be made. But the evidence is already sufficient to be seriously considered. It will be noted that those orders of mammals which show a retention of the Monotreme condition are admittedly primitive; and it may be further said generally that the greater or less persistence of this condition is in relation to their position in the series. Thus the Marsupials, Edentates, and Insectivora are, in the opinion of all zoologists, ancient groups. On the other hand, the Ungulates and Carnivora are more advanced in many ways, while the Primates are still more specialized in some respects. It is also noteworthy that of those types among the more modern and specialized groups which show the character under discussion, it is clear that they are more primitive types than are some of their allies. The Chevrotains stand below the Deer and Antelopes, and the Arctoid Carnivores ‡ are nearer to the common stem than are the Cats.

The differences observable among the genital veins are not a

* *Ibid.* p. 619 and references there quoted.

† Beddard, P. Z. S. 1909, p. 491, text-fig. 13.

‡ I take this opportunity of stating that in an example of *Mellivora signata* (in fact, the type specimen described by Pocock, *suprà*, p. 394) the postcaval was divided. The division ran up to just behind the entry of the left renal vein, as in an example of *Ictonyx* recently described by myself (*suprà*, p. 491). The right renal vein entered higher up. The ovarian veins were symmetrical and entered the divided postcaval; below them entered the also symmetrical lumbar parietal veins. No ovarian branches entered either renal vein. I have figured these veins in the memoir referred to (*v. suprà*, p. 491, text-fig. 131 A).

little remarkable. The Marsupials seem to be alone among the non-Monotreme Mammals in possessing invariably two pairs of spermatic (or ovarian—for the sex of the individual does not affect these veins) veins, one pair flowing into the postcaval direct and the other pair, often connected on its way with the former, opening into the renal veins. At least, it may safely be said that this is much the prevalent arrangement. And, furthermore, this group is also to be remarked upon as characterised by the symmetry of the posterior spermatic veins, though here the rule is not so universal. In other animals there would appear to be a persistence of either one pair of these veins or of the other; while some instances could almost seem to prove the retention of the left posterior spermatic vein and of the right anterior spermatic vein. The Dasypodidae are apparently a group in which the posterior spermatic veins are beginning to vanish. Both pairs occur in *Tatusia kappleri* and only the anterior pair in some other forms. The details I have already given and need not recapitulate here. The Insectivora are a group which are in the same condition as the Edentata. In *Centetes*, for example, there is no posterior spermatic vein, while there is such a pair of veins in *Erinaceus europæus* (at least occasionally). The higher Eutherian mammals, so far as they are known, never appear to possess both pairs of spermatic veins. More usually, as I hope to show shortly, the anterior spermatic vein persists on the left side and the posterior on the right. There are, however, a few forms in which it is the posterior pair only which remain, there being apparently in those forms no trace of the anterior pair. Thus in *Tragulus* and *Sciurus* it seems to be obviously the posterior pair which are the only spermatic veins. Furthermore, in those Carnivora (at any rate *Ictonyx* and *Mellivora*) which occasionally present us with a divided postcaval vein, the posterior spermatic veins persist on both sides, are symmetrical, and are the only spermatic veins. But in examples of *Ictonyx* where the postcaval is single and in other Carnivora where no such duplication has been recorded, the conditions are what may be called the typical Eutherian conditions, *i. e.*, the asymmetrical retention of veins.

This asymmetrical retention of veins seems to be connected with the formation of the renal and postrenal sections of the postcaval vein. As seems to be now fairly certain from the investigations of Hochstetter *, Lewis †, McClure ‡, and of Soulié and Bonne §, already referred to, that region of the postcaval in the higher mammals is developed from the right-hand subcardinal (or perhaps collateral cardinal) and right postcardinal only, the left disappearing. The spermatic veins, therefore, on the left side obviously lose their connection with the postcaval through the disappearance of the intermediate veins. When the development is symmetrical, as in *Tragulus*, *Mellivora*, &c., the genital veins

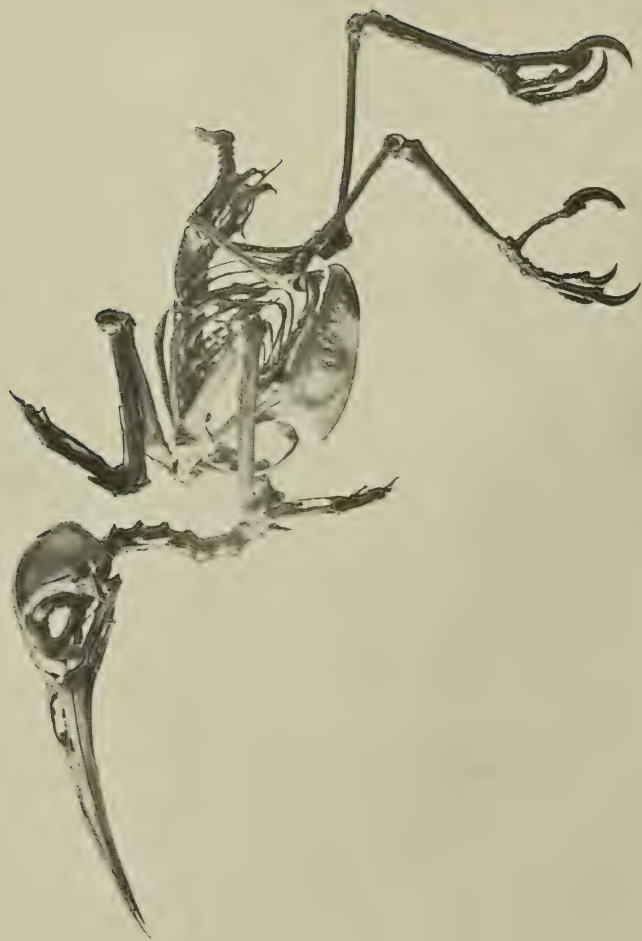
* *Loc. cit.*

† "The Development of the Vena Cava Inferior," Amer. Journ. Anat. i. 1902, p. 229.

‡ *Loc. cit.*

§ *Loc. cit.*

are also necessarily symmetrical. Here are both embryonic veins preserved with their branches, naturally equivalent on both sides of the body. But in the other cases, the spermatic vein of the left side only retains its connection with the cardinal (doubtless through the rich anastomoses which occur in the embryo), and follows the course of that vein anteriorly, opening into the renal in the left side. This point of view is confirmed by a consideration of those cases (of which I have described two in the present communication) where the left subcardinal or cardinal collateral, as the case may be, is converted into the postrenal section of the postcaval; here the conditions of the spermatic veins are precisely reversed, as would be expected on this view. There remain, however, some instances which can perhaps be disposed of on this hypothesis. There is, for example, the single postcaval vein in the genera *Sciurus* and *Zapus*. As to the latter, however, it is quite possible that its median position is significant. It may be that the two veins of the embryo which are connected with the formation of this part of the postcaval have both persisted and fused together, which would at once account for the median position and for the retention of both posterior spermatic veins. In the Squirrel, on the other hand, the postcaval postrenally is distinctly developed to the right of the aorta as in most Mammals. Still we know nothing of the development of the veins in this mammal, and a study of the development might show that there was after all a fusion of right and left veins of the embryo. Besides these cases we have the peculiarly constant mode of connection of the spermatic veins with the postcaval in the Murine Rodents—in many of them at any rate, in *Notiomys* to take a definite example. Here we have a symmetry between the spermatic veins but of a different kind to that which occurs in other animals, save for a few exceptions. The left spermatic opens into the left renal, while the right spermatic is symmetrical with it and therefore does not open into the renal of its side but into the postcaval opposite to the point of entrance of the left renal. In these cases it appears to me that we may have the disappearance of both posterior genital veins and the retention of both anterior veins. This is, of course, in the absence of embryological data sheer surmise; but we already know of cases where this appears more definitely to be the case, such as a number of Armadillos and the Insectivore *Centetes*. I believe that the cases which have now been considered exhaust the variations known to exist in mammals. From an evolutionary point of view it seems likely that the existence of two pairs of spermatic veins is the more primitive state of affairs, since these veins are more numerous in the lower Amniota, and that the prevalent arrangement of these veins as one pair is the later state. This also (it will be observed) agrees with the mutual relations of the groups of mammals which are here dealt with.



SKELETON OF ARACHNOTHERA MAGNA.

4. On the Comparative Osteology of the Passerine Bird
Arachnothera magna. By R. W. SHUFELDT, M.D.,
 C.M.Z.S.

[Received March 30, 1909.]

(Plate LXVIII.*)

A number of years ago Mr. F. E. Beddard kindly sent me for examination, from the Society's Collections, some twelve or thirteen alcoholic specimens of birds representing a variety of genera and species from several parts of the world.

It was only very lately that I could give this valuable material the attention it deserved, and upon comparing it with the list submitted the following forms were found to be at my disposal:—

No.	No.
289. <i>Cyanerpes cyanea</i> .	306. <i>Cereba chloropyga</i> .
345. <i>Arachnothera longirostris</i> .	718. <i>Acanthorhynchus</i> sp.?
318. " <i>magna</i> .	365. <i>Prosthemadera novæ-</i> <i>hollandiæ</i> .
497. <i>Leptocoma grayi</i> .	702. <i>Entomyza cyanotis</i> .
340. <i>Cinnyris chalybeus</i>	725. <i>Acanthogenys rufigularis</i> .
426. <i>Diglossa baritula</i> .	712. <i>Climacteris scandens</i> .
500. <i>Anthreptes malaccensis</i> .	

All these specimens had been in strong spirit for many years; some of them for perhaps twenty years, or even longer. This treatment had very much hardened all the soft tissues and muscles, and, as some of the species are very small and delicate, the labour of cleaning the skeletons was considerable, as I know from the fact that I performed the entire task myself. In some instances, in too many unfortunately, the extremely minute and fragile bones—in such a species, for example, as *Cinnyris chalybeus*—simply refused to hold together. Some of the specimens had been rather roughly eviscerated, thus injuring the skeleton in the neighbourhood of the incision. One or two were headless, and in the case of all some enterprising and enthusiastic ornithotomist had cut down to examine the xiphoidal extremity of the sternum, a perfectly justifiable operation, by the way, and doubtless to ascertain whether it was "notched" or otherwise, that is, passerine or trochilidine. Aside from these various mishaps, which are comparatively few when one comes to think how long all these specimens had been in the hands of science, this material as prepared offers not a little worthy of study and comparison.

The list has been kindly looked over by Dr. Chas. W. Richmond,

* For explanation of the Plate see p. 544.

Assistant Curator of the Division of Birds of the U.S. National Museum, to whom my thanks are extended for having pointed out the changes made in the nomenclature of three of the families, and for having brought up to date the present known habitats of the species represented.

In this list the genera *Cyanerpes*, *Diglossa*, and *Cæreba* belong to the family Cerebidae; *Arachnothera*, *Leptocoma*, *Cinnyris*, and *Anthreptes* to the Nectariniidae; *Acanthorhynchus*, *Prothemadera*, *Eutomyza*, and *Acanthogenys* to the Meliphagidae; and, finally, *Climacteris* to the family Certhiidae.

Again, and designating the species in the list by their numbers, we are to observe that No. 289 occurs in S. Mexico to S.E. Brazil and Cuba; No. 345 in the Indian Peninsula to Burmese Provinces and Malay Peninsula; No. 318 in the Himalayas to Burmese Provinces; No. 497 in the Celebes; No. 340 in S. Africa; No. 426 in S. Mexico and Guatemala; No. 500 in Siam to the Malay Peninsula, Java, Sumatra, Bali, Borneo, and Sulu and Tawi Tawi groups, P.I.; No. 306 in Cayenne to S.E. Brazil and Bolivia; No. 718 in Australia and Tasmania; No. 365 in New Zealand; Nos. 702 and 712 in E. and S. Australia; and No. 725 in S.S.E. and West Australia. Thus it will be seen that the species are found to range through Southern Mexico, Bolivia, South-eastern Brazil, West Indies, South Africa, widely over India and the East Indies, Australia, and New Zealand. They are all tropical or subtropical species, and none of them occur in North America north of Southern Mexico; none in any part of Europe or in the larger part of Asia.

My reasons for selecting from the list one of the species of *Arachnothera* as the principal form of which the osteological characters will be given in preference to any of the others are that, practically, the genus is from the centre of the region of the world's avifauna where the other families represented find their habitats, the regions considered being large continental areas of the earth's surface. Secondly, two species of *Arachnothera* occur in the list, and the skeleton afforded by the specimen of *A. magna* is the most perfect of any of those obtained. Finally, in any comparative anatomical work it is always best to select some special form, be what it may, wherewith to compare the structural characters presented on the part of all its supposed-to-be congeners, material for which may be at hand.

THE SKULL.—Viewing this part of the skeleton upon its superior aspect, it is to be observed that the cranial portion is globular in form, smooth, and is marked, mesially, by a broad shallow furrow that runs forward and to the right, to be lost at the cranio-facial line. This furrow is far better marked in *Arachnothera longirostris*, and in both species affords lodgment in life for the *thyrohyals* or "greater cornua" of the hyoid arches. A similar groove is found in the same locality on the skulls in the Trochilidae, only

in those birds it is better marked as a rule, and carried further backward, having the supraoccipital prominence standing between the furrows after the common one separated posteriorly. This character is also a feature of the skull in *Acanthorhynchus* among the Meliphagidæ and probably other honey-sucking species which possess tongues, the thyro-hyals of which curl over on top of the skull and are extensible. *Cinnyris chalybeus* is another example.

In *A. magna* the frontal region is rather broad between the peripheries of the orbits, and still broader in front of the lacrymals, where the cranio-facial line is quite distinct. The superior mandible seen from above is smooth and the culmen rounded. This part of the skull can best be studied on side view. Here it will be noted that it is gently decurved for its entire length, which is just double of that of the rest of the skull. It tapers very gradually to the sharp apex, while its tomia possess clean cutting-edges. The rather large elliptical external narial apertures open far back just beyond the cranio-facial hinge, or rather line (see Plate), and they have no true bony partition separating them mesially. This is entirely different from what we find in the Humming-birds, where these mandibular narial openings are long and slit-like. They are very large, and occupy a mid-position on the bill in such species as *Prothemadera novae-hollandiæ*, *Acanthogenys ruficularis*, and other Meliphagidæ, forms with shorter and stouter mandibles.

We find that *A. magna* has a capacious orbital cavity, with its osseous walls fairly entire. The *pars plana* is large and thick and faintly shows above its union with the lacrymal. Its outer margin, forming a part of the periphery of the orbit, is, like the rest of this margin round to the postfrontal, sharp and defined. On its orbital side the *pars plana* is markedly concave, but convex in front, while below it meets the anterior end of the quadrato-jugal bar. The latter is almost of hair-like proportions, very delicate, and straight. This is also the case in other species of the Nectariniidæ, some few Meliphagidæ, and in the Trochilidæ. Nearly all of these birds have a vacuity of a greater or less size in the *interorbital septum*, and the openings for nerves on the anterior wall of the brain-case, within the orbit, as those for the first pair, are large, and in *A. longirostris* merge with the foramen in the interorbital septum. The optic foramen, however, is generally distinct, and in such a species as *Climacteris scandens*, and probably its near allies, there exists no deficiency in the orbital septum, while the brain-case above exhibits a very large opening into the orbit.

Owing to the extreme slenderness of the osseous structures at the roof of the mouth posteriorly, the floor of the orbital cavity is distinctly deficient in bone, and this is the case with all the species in this genus, as well as in some of the related forms. On the lateral aspect of the cranium we find the *postfrontal process*

so feebly developed as to be barely noticeable, while the *squamosal process* below it is rather long, though extremely slender. The valley between them is only fairly well-marked. Humming-birds exhibit similar characters with respect to these two apophyses, but, taken as a whole, there is nothing, beyond the big *pars plana* in one of this family, to remind us of the orbital cavity as a whole in *Arachnothera*. To be sure, the anterior wall of the brain-case is deficient in bone in both, markedly so in the Trochilidæ, but, in so far as that goes as indicating any affinity between the two groups, it stands for very little.

The external aural aperture in the skull of *Arachnothera* is large, and admits of a full view of the interior of the bony ear. Posteriorly, and to some extent below, this entrance is protected by a thin scroll of bone, seen in so many other passerine forms, and very prominent in the Trochilidæ*. Among some of the Cerebidæ, as, for example, in *Diglossa baritula*, these bony parts of the external ear are remarkably developed; the aperture upon either side looks directly to the front, while the bulbous, thin, and scroll-like wall protecting it above, behind, and below is a striking feature upon this aspect of the cranium.

Posteriorly, the skull of *Arachnothera* offers but little for examination beyond what we would find in the skull of any ordinary passerine bird. The *occipital ridge* is but faintly defined, while the *supra-occipital prominence* is above the average in size, and especially so in *A. longirostris*. This is also seen in *Trochilus*, whereas among the Meliphagidæ it is not the case.

Passing to the *basis cranii* we have to note the large subcircular *foramen magnum*, and the extremely minute *occipital condyle*, which is distinctly hemiglobular in form. The basitemporal area is smooth and convex throughout, presenting at the usual localities the foramina for the entrance and exit of vessels and nerves to and from the cranial cavity. The double entrance to the Eustachian tubes, one to either side, is shielded below by a very narrow rim of bone. The basi-presphenoidal rostrum presents nothing peculiar, and is thoroughly coössified anteriorly with the mesethmoid and the *pars planæ*.

The *quadrate* possesses a sharp, compressed orbital process, that in articulation comes in close contact with the cranium. Its mandibular facet for the lower jaw is double, there being a small mesial elliptical facet and an outer and larger irregular-shaped one. A longitudinal groove stands between them. As usual, the mastoidal articular head is double, and the bone, as a whole, is highly pneumatic. Apart from the quadrates, all the other osseous structures at the base of the cranium in *Arachnothera* are characterised by extreme slenderness and delicacy of structure. And, in passing, it may be said that all the articulations,

* SHUFELDT, R. W. "Contribution to the Comparative Osteology of the Trochilidæ, Caprimulgidæ, and Cypselidæ." P. Z. S. Lond., Dec. 1, 1885, pl. lviii. fig. 2.

especially at the base of the skull, in this genus of birds are notably small, to the very limits of minuteness. This includes the articulation of the skull with the spinal column, the quadrato-jugal articulation, those with the *pterygoids*, and to some extent others.

These last-mentioned bones are very slender, straight, and rather short, presenting nothing peculiar in their articulations with the quadrates and palatines. They do not appear to be in contact with each other in the middle line, though they do articulate with the sphenoidal rostrum.

The postpalatine portion of either *palatine* is a delicate scroll of bone that articulates mesially with its fellow of the opposite side beneath the presphenoid, while the prepalatine portions are well apart, straight, and here reduced to a degree of slenderness rarely met with in birds of this size. A *vomer* is well-developed, spatulate in outline, and compressed throughout in the vertical direction. It is firmly coössified with a palatine upon either side. Each *maxillo-palatine* is reduced to the extreme in the matter of delicacy of structure, being but feebly developed.

Coming to the *mandible* it is to be observed that it has the long V-shaped pattern, with a curvature for its anterior two-thirds corresponding to the curvature of the upper jaw, while its posterior third is somewhat flexed upon the anterior part of the bone (see Plate). The rami are very slender and very narrow from above downward, the structure upon the whole impressing one with its feebleness. *A. magna* has the length of the symphysial portion about equal to the posterior moiety of the bone; in *A. longirostris* it is considerably longer, and in this species, too, the curvature is greater and, if anything, the bone still weaker. Inferiorly, the symphysis is smooth, and roundly convex transversely; the tomia for this part being sharp. A small "ramal vacuity" is present in the mandibles of both these species, and the free ramal extremities are more or less pneumatic. There is at each end a small blunt postangular process, otherwise these ends are practically truncated and concaved behind. The usual inturned angular processes are present, each having at its tip or apex the pneumatic foramen found there in so many of the Class. The *coronoid processes* are aborted. In *A. longirostris* the mandible is 4.8 cm. long and only 2 mm. deep at its deepest part, about opposite the ramal vacuity.

When normally articulated, the superior and inferior mandibles in the skull of *Arachnothera* are in contact for their entire lengths. I find nothing to note especially in regard to the intrinsic ossicles of the internal ear, the *siphonium*, or the *sclerotals* of the eye. All are exceedingly passerine in character.

For a representative of this group, however, the *hyoid arches* in this species are remarkable. Not only is the *glossohyal* greatly elongated to meet the requirements of the feeding-habits of the bird, but the *thyrohyals* are similarly produced. The

distal ends of the latter run out to hair-like proportions, which in life curve over the top of the skull, being harboured in the groove there formed for their reception. This admits of very considerable extension on the part of the tongue. The *ceratobranchial* elements of the thyro-hyals are very long, each being about half the length, or rather less, than the corresponding *epibranchial*. They are more or less straight, and take no part in the curvature of the posterior ending of this lingual apparatus. The *basihyal* is very short, and possesses, distally, a circular tip for articulation with the glossohyal. A slender, very short, straight *urohyal* is present; the heads of the ceratobranchials articulating, one on either side, at the junction of the basi- and urohyal.

A. longirostris has the skeletal parts of its tongue as they exist in *A. magna*. The general structure is the same among most of the Meliphagidæ; but in that family there exists no marked elongation of either the glossohyal anteriorly or of the thyro-hyals behind. In them the lingual apparatus is typically passerine. Exceptions to this rule, however, exist, and in such long-billed forms as *Acanthorhynchus* and some few others the skeleton of the tongue agrees more or less with what has just been described for *Arachnothera*.

Glancing for the moment at the skulls of other species representing other families at hand, it is to be noted in the skull of such a bird as *Diglossa baritula* that in the case of the interorbital septum it is almost entirely absorbed, a very thin and extremely narrow piece of bone simply spanning its centre, and the minutest possible spanlet below is just sufficient to individualize the two foramina rotunda. The anterior wall of the brain-case immediately above where these two striplets of bone join is entirely absent except a very narrow strip just within the orbital borders. Its occipital condyle is barely any larger than is to be found in *Trochilus*, and its sphenoidal rostrum is much compressed from side to side. Anteriorly, the rhinal chamber is very poorly off for bony protection, inasmuch as the elliptical external narial apertures are very large for the size of the beak: there is not a vestige of an internasal septum, while the *palatal processes* of the premaxillary almost require a lens to see them at all. In this species the ramal vacuities of the mandible are larger than we find them in *Arachnothera*, although the latter is a bird double its size.

Cinnyris chalybeus presents some interesting cranial characters of its own, for here we find the *nasal bones* reduced to their very minimum proportions; the external narial openings are large, being barely separated above by the culmen. *Pars plana* are much reduced in size, and the fronto-interorbital area on the superior aspect of the skull of this species is notably narrow transversely. Its *mandible* is feebly constructed, and the whole beak considerably decurved.

In *Cœreba chloropyga* the skull is typically passerine, and in some respects resembles the skull as found in certain American Warblers, being quite distinct from what we find in *Arachnothera*, to which genus it bears no special affinity.

So entirely different is the skull in such a species as *Prosthemadera novæ-hollandiæ* of New Zealand, a bird placed among the Meliphagidæ, that a separate description would be required to give an account of it. Here the *nasals* are very broad antero-posteriorly, and each is pierced by a central foramen, an unusual character. Then the *pars planæ* are very thick from before backwards, and a longitudinal groove marks the external aspect of each.

In not a few particulars *Acanthogenys ruficularis* of Australia is a Meliphagidine species with a skull not at all unlike what we find in the species of *Acanthorhynchus*, and these forms are more or less nearly related. *Acanthogenys* has the broad nasals, each pierced by the small central foramen, and there are several other points in the two skulls of more or less close agreement. But such representatives of the Meliphagidæ have no special relationship with the Cœrebidæ, and even less with the typical Nectariniidæ. Judging from the skulls alone, it is not difficult to recognize the more or less close relationship existing among the species I have before me of the genera *Entomyza*, *Acanthogenys*, and *Prosthemadera*, all of which present characters in this part of the skeleton quite different from anything we find in *Arachnothera*, and surely offer no skull-characters at all approaching any of the Trochilidæ.

I have made no attempt to either study or compare the ossifications presented on the part of the tracheæ in any of these birds. From superficial examination only, I would say that although generic and family differences are easily to be seen in these parts, yet at the same time no very striking departures are to be noticed from the general passerine character in any of them.

Having then compared the morphological characters of the skull and the associated osseous structures in such species as there are at hand representing the families Cœrebidæ, Nectariniidæ, Certhiidæ, and Meliphagidæ, and these characters with the corresponding ones in the skull of *Trochilus*, it is clear that, in so far as this part of the skeleton is concerned, these four passerine families are a very long way removed from the Super-suborder *Trochiliformes*, and this is no more than one would naturally expect to find.

My views upon the position in the system of the four above-named families have already been published, and I see no special reason for changing them *. From this point on any further comparison of the skeletons of these birds with the osteology of

* SHUFELDT, R. W. "An Arrangement of the Families and the Higher Groups of Birds." Amer. Nat. vol. xxxviii. nos. 455-456, Boston, Nov.-Dec. 1904, pp. 835-856.

the Humming-birds would be quite unavailing. In all respects it is very different. I shall proceed, then, to complete this account with a description of the remainder of the axial skeleton and the skeleton of the limbs in *Arachnothera*, comparing the principal characters with those presented by the skeletons of the other families above-named.

REMAINDER OF THE AXIAL SKELETON.—So far as the vertebræ are concerned between the skull and the pelvic sacrum, the several families of birds here being considered are all strictly passerine in character. I have counted and compared them in a representative of each family, and am satisfied that these bones offer nothing worthy of an extended and detailed description. To be sure, we find some differences in form among the various species, genera, and families, but such characters are of but slight importance, and in all instances the variations are no more marked than those which obtain among more or less nearly related passerine birds in the avifauna of any country of great extent, as, for example, in *Sialia*, *Mimus*, and American Warblers, as compared with the Passeres of the Pacific Coast region*. Both *Arachnothera magna* and *A. longirostris* possess 19 vertebræ between the skull and the pelvic sacrum; the first twelve are true cervical vertebræ without free ribs. The 13th and 14th are also cervicals, the first supporting a pair of very small free ribs, and the last a far better developed pair, which are likewise free and without *unciform processes*. The next five are true dorsals and possess these appendages, and also connect with the sternum through the intervention of *costal ribs*. We also find a very delicate pair of ribs attached to the leading vertebra of the sacrum, the sternal ribs of which are "floating ribs." Dorsal vertebræ have well-developed neural spines which are in contact with each other anteriorly and posteriorly, the ultimate dorsals being lacking in hæmal spines.

There are *seven* free caudal vertebræ in the skeleton of the tail in *A. magna*, in addition to a rather large *pygostyle*. The form assumed by the latter is well-shown in the Plate illustrating this paper. In the family Meliphagidæ there appear to be but *six* caudal vertebræ and the *pygostyle*, and this is likewise the case among the Cœrebidæ, as, for example, in *Cyanerpes cyanea*. However, we know that even in the same species these caudal vertebræ may vary to the extent of one, or may be two; they are not constant even in our own species.

As well as can be made out from an adult skeleton, or rather a skeleton from an adult individual, it would appear that there are *eleven* vertebræ fused together to form the pelvic sacrum in

* SHUFELDT, R. W. "Contributions to the Comparative Osteology of the Families of North American Passeres." Jour. Morph. vol. iii. no. 1, Boston, June 1889, pp. 81-114, pls. v. & vi. A large number of the passerine birds of the United States are osteologically compared in this paper.

A. magna, and they present the usual passerine characters. Only *ten*, it would seem, are thus fused together among the Cœrebidæ, but in these birds the pelvis is relatively shorter and wider than it is, as a rule, among the Nectariniidæ. The Meliphagidæ have eleven—that is, in the species at hand, though *Acanthogenys ruficularis* may be an exception and possess only *ten*; in any case, an extra vertebra in the sacrum may account for one less in the caudal series.

Among all small, ordinary, and more or less typical Passeres all over the world where they may occur, we meet with but little variety in the form of the *pelvis*. Its passerine characters are very uniform. Some birds of the group have it rather narrow and deep; in others it is wider and more compressed from above downward, with the pubic elements far apart—but the *general* characters remain the same. In *A. magna* it is of the narrow and deep variety, with the *ilio-neural canals* open for their entire lengths, and the “sacral crista” standing between them very prominent. On the postacetabular area parial foramina occur among the diapophyses of the ultimate sacral vertebra. Anteriorly the ilia are truncated from their mesial angles, backward. Posterior to an acetabulum, on a side view, we note the large *ischiodic foramen*; a small, circular *obturator foramen*, which is barely separated from the large *tendinal vacuity*. Behind this last the ischium dips down, as usual in Passeres, to meet the pubis, or pubic style, near its distal termination. The postacetabular, external free margin of the ilium to some extent overhangs the ischiodic foramen, while the preacetabular part of one of these bones is hollowed externally throughout its extent. The pelvis exhibits specific differences in *A. longirostris*, where the postsacral foramina are large, and the internal iliac margins in the postacetabular region do not coössify with the sacrum.

Among the Meliphagidæ, we find that in *Entomyza cyanotis* the ilio-neural canals or “grooves” remain open only anteriorly, and this is the case with other species of this family. On lateral view of this pelvis all the openings are very large, the osseous side of the bone here being reduced to the minimum thereby. This statement refers also to the large circular *cotyloid ring* (acetabulum) and the mergence of the obturator foramen with the tendinal vacuity. In *Cyanerpes cyanea* the essential characters are the same, but the pelvis, as a whole, is broader and flatter than it is in *Arachnothera*, coming in this respect nearer some of the Nectariniidæ, as, for example, *Anthreptes malaccensis*.

Passing to the *shoulder-girdle* and *sternum*, we find all this part of the skeleton very distinctly passerine in character, the matter of size of the bones often being all there is to differentiate them with respect to the species they belong to: as, for example, the *os furcula* of such a species as *Prosthemadera novæ-hollandiæ* is, as

we would expect, a larger bone than the *os furcula* of *Arachnothera magna*, yet the characters are identically the same, so much so that were the bone in the latter brought up to the size of the one in the former, I very much doubt that any ornithotomist could, with certainty, tell them apart. Indeed, the *os furcula* possesses in all the passerine birds here under examination the same form and characters. When we say it is U-shaped in outline, has a large, transversely compressed, and up-turned hypocleidium, slender limbs, and expanded clavicular heads, we have said about all there is to be said in regard to it.

All these birds have *coracoids* and *scapulae* of the shoulder-girdle very much alike indeed—that is, apart from the matter of size. The morphological variations are very insignificant and offer little or nothing of taxonomic value. It is interesting to note, however, that irrespective of the length or form of the beak, we find in all the Meliphagidae that the lower external angle of the expanded part of a *coracoid* is produced outwards as a distinct, flattened process, best seen in the short-billed species, though also well-marked in *Acanthorhynchus*, which Dr. Richmond informs me is a genus belonging to the family Meliphagidae. Now, in *Arachnothera*, and in all the Nectariniidae and Corebidae at hand, that angle of the coracoid is more or less *truncated*, but whether this points correctly to any existing relationships of the families named, it would be difficult to say*.

Representatives of all these families at hand, as in all true Passeres I believe, have at each shoulder-joint an *os humero-scapulare*, and it varies but very little in size and form in the species examined. When we come to examine the *sternum* of *Arachnothera magna* and compare it with the sterna of other species of Nectariniidae, and with the other bird-forms enumerated in this paper, we once more realize that this part of the skeleton is likewise all passerine in its morphology, presenting only a few slight differences for the various species. Still, apart from the variations in size, these differences are more or less constant, and in any case unmistakable with respect to the sternum of the species possessing them—that is, the species which have thus far been named in this paper. The sternum in all exhibits a number of characters which all the sterna present in common, as the large, upturned trihedral *manubrium*, with its bifurcated free extremity; the lofty *costal processes* with the haemapophysial facets on the posterior borders; the marked concavity of the

* Without going into details, and judging from the skeletons alone, I would remark that the Australian genus of birds named *Acanthorhynchus* which have been referred to the Meliphagidae possess skeletal characters which in the main agree better with the corresponding ones in *Arachnothera* than they do with any of the same characters as seen in the short-billed Meliphagidae. But two species of *Acanthorhynchus* are known to me, *A. tenuirostris* and *A. superciliosus*, and these I have never had the opportunity of comparing in the flesh with the meliphagidine birds of Australia and New Zealand.

dorsal aspect; the pair of "notches" in the xiphoidal extremity giving rise to an outer xiphoidal process upon either side; the deep "keel" with its prominent carinal angle, anteriorly; and, finally, the fact that the bone is more or less pneumatic. The coracoids never decussate in their sternal beds, though in some species they almost appear to do so. Again, the hypocleidium of the furcula never comes in contact with the manubrial process of the sternum, though in some species the approach is extremely close (*Entomyza cyanotis*). So much for the general characters, and *Arachnothera* has them all to perfection; and there are a few minute *pneumatic foramina* in the middle line on the dorsal aspect of the bone, anteriorly, in this species. If we designate the *length of the sternum* by a line extending from the apex of the carinal angle of the keel to the mid-xiphoidal point posteriorly where the keel terminates, then this distance in *A. magna* measures 2·3 centimetres. This same measurement will be applied in the case of the sterna of the other species—as, for example, in *Arachnothera longirostris*, the length of the sternum is but 1·5 cms., and we find the body of the bone *flatter*, the xiphoidal notches comparatively deeper, the carinal angle not so acute, and the keel of the manubrium conspicuous and produced well down upon the anterior border of the sternal carina. The pneumatic foramina are scarce and in the same locality. In *Leptocoma grayi* the sternum has a length of but 1·3 cms. In *Cyanerpes cyaneus*, as representing the Cœrebidæ, it measures 1·7 cms., and here the bone is very thin and delicately constructed, with a small manubrium; deep notches and dilated extremities to the xiphoidal processes. These characters do not apply to the sternum of *Cœreba chloropyga*, another of the Cœrebidæ, a species having the bone only 1·2 cms. long.

Anthreptes malaccensis has a sternum which is the counterpart of that bone in *A. magna*, only it is much smaller, having a length of but 1·4 cms.

Among the larger forms of the Meliphagidæ we meet with characters in the sternum that are absolutely diagnostic, as, for example, there is no such a thing as mistaking the species had we but this bone to help us in such a bird as *Acanthogenys ruficularis*. Here, although it is of the usual passerine type, it is peculiar in having the anterior border of the sternal body very much thickened and rounded; this thickening is continued across the base of either costal process and up on to the mesio-posterior margin of the same. Such a thickening also defines the limits laterally of a deep mesio-longitudinal groove, deepest anteriorly, that is found upon the dorsal aspect of the body of the bone. For its anterior moiety, thickly crowded together at the bottom of this groove, we find some thirty or forty pneumatic foramina openings. Between the coracoidal grooves there is another single pneumatic foramen, and the external angles of the mid-xiphoidal prolongation are pronounced. The carinal angle is

not prominent and is to some extent slightly rounded off. Thus it will be observed that this meliphagidine species possesses a very characteristic sternum, quite different from the bone in *Arachnothera*.

In *Entomyza cyanotis* the sternum, of course, is somewhat larger, and in it the anterior border of the body is thickened and the mesial groove with its pneumatic foramina on the dorsal aspect is confined to the anterior third of the bone. The *carinal angle* is sharp again and rather prominent, while the most distinctive character of this sternum is the unusually short manubrial process, though its bifurcations are conspicuous. In this bird I should have noticed above that the *coracoids* are very long and particularly slender.

In *Prothemadiera novæ-hollandiæ* the sternum is likewise distinctive, in that the above-described mesial groove on the dorsal aspect is *absent*, and the pneumatic foramina in that locality are reduced to a very few minute and hardly noticeable ones. Very little thickening of the anterior sternal border is to be observed, and the carinal angle is not produced anteriorly. As compared with other Meliphagidæ, however, the sternum of this species may be easily recognized by the remarkably thickened free anterior border of the manubrium, which is extended more than halfway down upon the anterior border of the keel. Then, posteriorly, the external lateral xiphoidal processes are unusually slender and long. Distally, on either side, they almost touch the greatly produced outer angle of the mid-xiphoidal prolongation, thus giving the much elongated "notch" upon either side the appearance of a foramen.

Posteriorly the keel terminates in a conspicuous triangular area, and, as usual, there are *five* hæmapophysial facets on the posterior border of either costal process.

Entomyza cyanotis has the sternum 3.2; *Acanthogenys rufigularis* 2.6; and *Prothemadiera novæ-hollandiæ* 3.1 centimetres long.

So far as any characters go, the sternum of the last-named species is most like the bone in *Arachnothera magna*, and this seems to be true with respect to some other parts of its skeleton. Whether this circumstance carries with it the fact that these two species are more nearly affined than either of the other two meliphagidines just named remains to be seen. It would require more extensive and varied material, I must believe, to be certain of such a point as this.

OF THE APPENDICULAR SKELETON: THE PECTORAL LIMB.—With great care I have examined and compared the bones of both the pectoral and pelvic limbs in the birds named in the list presented in the first part of this paper. This part of the osseous system has likewise been studied by me in a very large number of passerine species from various parts of the world. The

forms here being examined are from Mexico, South America, South Africa, Asia, East India, New Zealand, and Australia, or, in other words, very widely separated countries, yet there is no mistaking any of the characters of the skeleton of the limbs in any of the birds,—they are all distinctly passerine, we might say “typically” passerine, had there ever been selected as a reference standard a species anywhere, the skeleton of which was to be universally considered as the *type* in this respect for all Passeres. It would be interesting to know what species would be selected upon a consensus of opinion of ornithotomists everywhere, on this point—*Merula* perhaps. Typically passerine or otherwise, however, one would be surprised to note the variations in form in some of these bones among these oscine honey-birds, creepers, and their kin. To appreciate this to the full extent, the skeleton of the limbs of the several species would have to be brought up, either in drawings or plastic models, to many times the size of the original, and *then* compared one with another. Take the *humerus*, for example: had we models of this bone from all the species in our list each twenty centimetres long, and the other proportions correctly reproduced, we should be surprised at the differences which exist in them, which by this means could easily be recognized at a glance, but which otherwise must be studied by passing from one to the other with a good lens to assist you.

In *Arachnothera magna* the *humerus* has a length of 2.2 cms., and its smooth shaft is nearly straight, presenting hardly any of the usual sigmoidal curve from whatever point we may view the bone. In form it is subcylindrical, being somewhat compressed, from its anconal aspect palmar. The *radial crest* is short and not very prominent, while the ulnar tuberosity is conspicuous, and the *pneumatic fossa* surrounded by a distinct raised margin, which between this concavity and the head of the bone on the anconal side is raised into a thin and projecting process. What is most peculiar is that the head of the humerus is *hollow* and the entrance to the concavity is seen on the anconal side, next to the pneumatic fossa, being separated from it by the aforesaid thin projecting process. A few small, scattered, pneumatic foramina are found at the bottom of the fossa, where they usually occur. At the distal end of the bone we find the oblique and ulnar tubercles much produced with the olecranon fossa circumscribed and well marked. It is confined to the ulnar side of the shaft. The ecte- and entepicondylar processes are both distinct though not large apophyses. In all these birds there is to be found a *free sesamoid* at the elbow-joint.

Arachnothera longirostris has a humerus resembling the bone in *A. magna*, but in it the *caput humeri* is not hollowed out in the manner described above. In both species there is a distinct and circumscribed pit at the distal end of the shaft on the palmar surface right next to the ulnar tuberosity. This humerus has a

length of 1·7 cms. Considering its size, the proximal end of the bone is expanded in *Leptocoma grayi*, and the processes at the distal extremity conspicuous; otherwise the characters are quite identical with those in the humerus of *A. magna*. It has a length of 1·3 cms.

Cinnyris chalybeus has the caput humeri but very slightly hollowed out, and the bone has almost the appearance of being non-pneumatic. In any event, by the aid of a strong lens, I failed to find pneumatic foramina at the base of the fossa. The radial crest is considerably aborted, and a long shallow notch cuts out a portion of its free continuity. The bone is 1·2 cms. long.

Among the Cerebidae, *Diglossa baritula* has a non-pneumatic humerus, measuring in length 1·2 cms. Its distal processes and tuberosities are made conspicuous by their distinctness—clean-cut and produced, as it were. There is not a little hollowing out of the head of the bone next to the pneumatic fossa, the concavity being fairly well separated from the latter by a thin osseous partition, as in *A. magna*. These two cavities practically merge in such a form as *Anthreptes malaccensis*, and the partition between them in other species, though well produced, has withdrawn toward the proximal end of the bone. It has a length of 1·6 cms. and appears to be non-pneumatic.

In *Cyanerpes cyanea* this mergence of the pneumatic fossa and the very profound excavation of the caput humeri is practically complete—the merest vestige of an osseous partition existing between them. The radial crest is very short; and this humerus, too, appears to be non-pneumatic or very largely so. It has a length of 1·5 cms. Without particularly examining this bone in other Nectariniidae, Cerebidae, or Certhiidae—though it may be said with respect to the latter that in *Climacteris scandens* the humerus presents very different characters, for in it the caput humeri is not hollowed out at all, the pneumatic fossa is very open, the foramina large, the entire bone pneumatic, and the shaft somewhat curved (length 2 cms.)—we may pass to a study of the bone in the Meliphagidae. Here in *Acanthorhynchus*, *Entomyza cyanotis*, and *Acanthogenys ruficularis* the caput humeri never exhibits the slightest indication of any hollowing out or any cavity leading in to it next to the pneumatic fossa. The latter is large, deep, with its free margin much thickened, and the pneumatic foramina at its bottom big and more or less numerous, as the bone in these birds is highly pneumatic. The subcylindrical shaft displays to same degree the sigmoidal curve and in some species is stout for its length, as in *Prosthemadera nova-hollandiae*. The radial crest is short and not very prominent, while the tubercles and processes at the distal end are so.

Passing to the bones of the antibrachium, carpus, and manus we find that they present among these families, including

Arachnothera magna, fewer distinctive characters than do the humeri for the species examined. All are essentially passerine and more or less typically so. *Radius* and *ulna* of the forearm are invariably straight, and present the characters common to the group. On the shaft of the ulna the papillæ for the quill-butts of the secondary feathers of the wing may be very well pronounced (*Entomyza*) or entirely absent (*Arachnothera*, *Prosthemadera*, and most others).

The *middle metacarpal* is always produced beyond the main bone of the metacarpus—the index metacarpal,—and I have never met with any *claws* on any of the terminal phalanges. There is always present a triangular, flattened process at the proximal end, ulnar side, outer aspect of the index metacarpal which is directed backward and rests flat against the proximal end of mid-metacarpal.

Radiale and *ulnari* of the wrist are invariably well-developed and present the usual passerine characters.

THE PELVIC LIMB.—Upon comparing the bones entering into this extremity in *Arachnothera magna* with the corresponding ones as we find them in the legs of the cœrebidine, certhidine, and meliphagidine species at hand, it is to be observed that the characters upon the whole are more uniform than they are for the bones of the pectoral limb. Osteologically, the limb is of a strictly passerine type throughout, and when compared, bone for bone, with the limb in any of the non-passerine suborders, presents more or fewer differences. As a rule, in the former the long bones of the thigh, leg, and metatarsus are quite straight, and in the case of the femur and tibio-tarsus have cylindrical shafts. *Entomyza cyanotis* offers an exception in the case of the latter bone, for instead of its shaft being entirely straight it is seen to curve away from the fibula above the fibular ridge and approach it again proximally to articulate with the latter and the femoral condyles. This condition is not usually seen or is much less marked among other meliphagidine species. As in the case of the bones of the antibrachium and manus, all the bones of the pelvic limb are non-pneumatic, and the nutrient foramina that enter them are very minute.

In the *femur* the semi-globular head is sessile, and the pit for the *ligamentum teres* generally very feebly marked. Distally, the summit of the bone includes a part of the head, the great trochanter, and the valley between the two, thus forming one surface, which is articular, and lies in a plane to which the longitudinal axis of the shaft of the bone is perpendicular. Distally, the condylar end of the femur is well-developed and presents the usual passerine characters. The depth of the *rotular channel* varies in different species and families, being rather deep in *Arachnothera* and generally shallower in the Meliphagidæ.

As in the majority, if not in all, oscine passerines, the species

here under examination possess a well-developed osseous *patella*. As we would naturally expect, it varies in size for the species, but very little with respect to form. In *Arachnothera magna* it is of a cordate outline, with the much rounded apex below, convex anteriorly, and decidedly concave on its upper and posterior aspects. Posteriorly, the concavity is double, the surface between being intended to accommodate itself to the femoral condyles. In *Prosthemadera novæ-hollandiæ* the patella has a transverse diameter of half a centimetre, and is two millimetres deep at the centre.

Tibio-tarsus supports the usual pro- and ectocnemial processes, and these have their common passerine form, varying but slightly for any of the species here being examined. In all cases they rise but slightly above the summit of the bone; they extend only a very short distance down the shaft, and both are always turned slightly fibulawards. Their antero-inferior angles may be sharp-pointed (*Arachnothera*, *Careba*, and *Diglossa*) or they may be rounded off as in the Meliphagidæ. They are very conspicuous and far apart, and produced almost directly to the front in *Climacteris scandens*. Always feebly developed, the *fibula* is but rarely produced beyond, or much beyond, the fibular ridge on the tibio-tarsus in articulation. It is a weak bone, of but slight importance in all small passerine forms.

Tarso-metatarsus presents nothing of marked departure from the ordinary form of the bone among all small passerine birds. Its *hypotarsus* is always reduced to a small subcubical apophysis vertically pierced for the passage of tendons. The shaft is always more or less flat anteriorly, and longitudinally grooved behind. The three distal trochlear processes are found in nearly the same transverse plane, with a large, free *accessory metatarsal* directed backward.

As to the skeleton of the *pes* it is purely passerine in its morphology, with the joints of the toes on the usual plan. All of these species have the *ungual joints* large and much curved, especially is this the case with respect to the *ungual phalanx of the hallux* in the larger species of the Meliphagidæ.

Ossification in these birds, and probably in others, may normally extend to some of the tendons of the muscles at the back of the tarso-metatarsus between the hypotarsus and the accessory metatarsal of the hallux, which is markedly the case in *Entomyza*.

CONCLUSIONS.

It is clear from what has been brought out in this paper that none of the species of birds here osteologically passed in review, employing *Arachnothera magna* as the type, has any especial affinity with the Trochili. Even the morphology of the tongue in quite a number of the forms has no significance when taken in

connection with the rest of the anatomical structure, which in the Humming-birds is so decidedly non-passerine, while in all the families here investigated the osteology at least points most distinctly to the Passeriformes.

There are a few faint cranial resemblances to be seen upon comparing that part of the skeleton of a Humming-bird with the corresponding structures in certain Cœrebidæ, or even Nectariniidæ, but they amount only to resemblances and no more. These are interesting, but they have no bearing whatever upon affinities.

As to the probable relations of these several families—the Nectariniidæ, Cœrebidæ, Certhiidæ, and Meliphagidæ—to each other and to other groups, we are confronted with an entirely different question, and one by no means easy of settlement. In my paper on "An Arrangement of the Families and the Higher Groups of Birds" my provisional opinion has already been presented. There the Meliphagidæ stand between the Nectariniidæ and Certhiidæ—the three families being kept together and placed between the Dicaeidæ and Mniotiltidæ. From these the Cœrebidæ are well separated, being placed between the Drepanidæ and Tanageridæ, with several families intervening, including the Larks and Finches. I do not know that this opinion has in any way been shaken or disturbed by the examination of the material Mr. Beddard has so kindly placed at my disposal; still before my convictions come to be any firmer or more settled, I would prefer to investigate the anatomy of a great many more species of families evidently related, than I have up to the present time. Were I to propose a change in my arrangement I would say perhaps that the Cœrebidæ should hold a place in closer relationship to the Creepers and Warblers, which I am rather inclined to think that they do. As a family, however, the Cœrebidæ are undoubtedly very distinct, certainly from the Nectariniidæ, here made to include the former family Cinnyridæ. The examination of the skeleton of such a form as *Diglossa baritula* would be quite sufficient to establish that fact, and this has been done in the present contribution. A few more Sun-birds and Honey-suckers should be examined, especially of the genera *Drepanis* and *Meliphaga*, which I have not as yet seen. *Cinnyris* is a genus of the Nectariniidæ, though not typical of that family. I have in former years examined many of the Sittidæ—the Honey-creepers (*Cœreba*) are quite distinct from them.

Climacteris scandens as a representative of the Certhiidæ clearly points to the fact of the distinctness of that family, but I should like to examine the skeletons of other species of Wall-creepers.

A far greater number of the Meliphagidæ need investigation, and the genera here examined do not point, in so far as their skeletons go, to any very close relationship with the Nectariniidæ, as exemplified in the genus *Arachnothera* and others. Especially

does this required research apply to the subfamilies *Myzomelinae*, *Melithreptinae*, and *Meliphaginae*. Possibly the representatives of some of these are more nearly affined to such a species as *Arachnothera magna* than some we have seen. In any event my labour will not have been in vain if what has here been brought out with respect to the osteology of the four meliphagidine genera examined proves to be of any assistance in that direction.

EXPLANATION OF PLATE LXVIII.

Left lateral view of the skeleton of *Arachnothera magna*. Adult. Natural size.
Right ulna fractured at its proximal third. Preparation partly ligamentous ;
podothecæ not entirely removed. Reproduced from photograph of the specimen
by the author.

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ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

January 12th, 1909.

Prof. J. ROSE BRADFORD, M.D., D.Sc., F.R.S., Vice-President,
in the Chair.

The SECRETARY read a Report on the additions that had been made to the Society's Menagerie during the month of December 1908.

Dr. H. G. PLIMMER, F.L.S., F.Z.S., Pathologist to the Society, exhibited the Intestinal Tracts of two Snakes that had recently died in the Society's Gardens and called attention to the condition of inflammation present in them.

Prof. E. A. MINCHIN, M.A., V.P.Z.S., read a paper entitled "Observations on the Flagellates Parasitic in the Blood of Fresh-water Fishes," in which five species of *Trypanozoma* and four species (two new) of *Trypanoplasma*, from fishes of the Norfolk Broads, were described in detail. Particular attention was paid to the minute structure of the parasites, and it was shown that it is possible to give a uniform description for the nuclear apparatus of both *Trypanozoma* and *Trypanoplasma*.

Dr. W. A. CUNNINGTON, F.Z.S., read a paper by Prof. G. O. SARS, C.M.Z.S., entitled "Zoological Results of the Third Tanganyika Expedition, 1904-1905.—Report on the Copepoda."

* This Abstract is published by the Society at 3 Hanover Square, London, W., on the Tuesday following the date of Meeting to which it refers. It will be issued, free of extra charge, to all Fellows who subscribe to the Publications, along with the 'Proceedings'; but it may be obtained on the day of publication at the price of *Sixpence*, or, if desired, sent post-free for the sum of *Six Shillings* per annum, payable in advance.

In a paper communicated by Prof. T. W. BRIDGE, D.Sc., F.R.S., F.Z.S., and entitled "On the Gonadial Grooves of a Medusa, *Aurelia aurita*," the author, Mr. T. GOODEY, B.Sc., Zoological Laboratory, University of Birmingham, dealt with investigations which confirmed his earlier suggestion that the gonadial grooves, which lie in the interradian axes between the central gastric cavity and the gastric pouches, have a sexual function. From sectionised material, drawings had been obtained of spermatozoa and eggs lying within the limits of the gonadial grooves, thus proving that the latter are functional gonoducts.

The SECRETARY, on behalf of Mr. ARTHUR ERWIN BROWN, D.Sc., C.M.Z.S., Secretary of the Zoological Society of Philadelphia, read a paper entitled "The Tuberculin Test in Monkeys; with Notes on the Temperature of Mammals." The paper described the methods and results of experiments which have recently been carried out at the Zoological Gardens of Philadelphia with the view of suppressing tuberculosis in monkeys.

Mr. F. E. BEDDARD, F.R.S., F.Z.S., presented a paper by Prof. R. COLLETT, F.M.Z.S., "On *Balaena glacialis* and its Capture in recent Years in the North Atlantic by Norwegian Whalers."

The next Meeting of the Society for Scientific Business will be held on Tuesday, the 2nd February, 1909, at half-past Eight o'clock P.M., when the following communications will be made:—

1. Dr. C. W. ANDREWS, F.R.S., F.Z.S.—Notes on the Fauna of Christmas Island, illustrated by lantern-slides.

2. Dr. H. G. PLIMMER, F.L.S., F.Z.S.—Report on the Pathological Observations at the Society's Gardens during 1908.

3. H. S. LEIGH.—Preliminary Account of the Life-history of the Leaf-Insect, *Phyllium crurifolium* Serv.

4. E. C. CHUBB, F.Z.S.—The Mammals of Matabeleland

The following communications have been received :—

1. F. WOOD-JONES, B.Sc., F.Z.S.—The Fauna of the Cocos-Keeling Atoll.

2. GROUSE-DISEASE COMMISSION REPORTS :

(a) A. E. SHIPLEY, M.A., D.Sc., F.R.S., F.Z.S.—The Ectoparasites of the Grouse.

(b) A. E. SHIPLEY, M.A., D.Sc., F.R.S., F.Z.S.—The Thread-Worms (Nematoda) of the Red Grouse (*Tetrao scoticus*).

(c) A. E. SHIPLEY, M.A., D.Sc., F.R.S., F.Z.S.—The Tape-Worms (Cestoda) of the Grouse. Appendix: Parasites of Birds allied to the Grouse.

Communications intended for the Scientific Meetings of the ZOOLOGICAL SOCIETY OF LONDON should be addressed to

P. CHALMERS MITCHELL,

Secretary.

3 HANOVER SQUARE, LONDON, W.

January 19th, 1909.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

February 2nd, 1909.

FREDERICK GILLETT, Esq., Vice-President, in the Chair.

Mr. C. TATE REGAN, M.A., F.Z.S., exhibited specimens of the Char of Lough Melvin (*Salvelinus grayi*, Günth.) and of the Char from a little loch under Ben Hope, Sutherlandshire, recently described by him under the name *Salvelinus maxillaris*. He pointed out the differences between the two forms, and called attention to the interest attaching to the study of this too much neglected group of British freshwater fishes.

Mr. R. E. HOLDING exhibited several skulls and photographs of the St. Kilda or Hebridean Four-horned Sheep, and remarked upon the character of the horns of this curious form, pointing out some differences between them and those of the South-African and other Sheep having four horns.

Mr. C. DAVIES SHERBORN, F.Z.S., on behalf of Mr. MALCOLM MACLAREN, read an account of a fight between a Whale and a Swordfish observed in the Hauraki Gulf, New Zealand.

Dr. C. W. ANDREWS, F.R.S., F.Z.S., gave an account, illustrated by lantern-slides, of his visits to Christmas Island, calling attention to the differences in the fauna associated with influx of population.

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Mr. H. S. LEIGH, Honorary Research Fellow in the University of Manchester, presented a paper, communicated by Prof. Hickson, F.R.S., F.Z.S., entitled "Preliminary Account of the Life-history of the Leaf-Insect, *Phyllium crurifolium* Serville," and made the following remarks:—

"The Leaf-Insects occur in the tropical regions of the Old World and seem partial to insular life. The eggs, which resemble the seeds of certain plants to a remarkable degree, require to be kept in a constantly warm and moist atmosphere to enable them to hatch; they hatch very irregularly, and the period of incubation often extends over three or four months. When young the larvæ are active as compared with older individuals. The metamorphosis is incomplete, and the adult form is attained by a gradual increase in size; fully-developed tegmina and wings only appear in the adult condition. The adult females are large and leaf-like in appearance, but the males are much smaller and not foliaceous."

Mr. E. C. CHUBB, F.Z.S., Acting Curator of the Rhodesia Museum, communicated a paper on "The Mammals of Matabeleland."

Dr. H. G. PLIMMER, F.L.S., F.Z.S., Pathologist to the Society, reported on the Pathological Observations at the Society's Gardens during 1908, and illustrated his remarks with a series of lantern-slides.

The next Meeting of the Society for Scientific Business will be held on Tuesday, the 16th February, 1909, at half-past Eight o'clock P.M., when the following communications will be made:—

1. F. WOOD-JONES, B.Sc., F.Z.S.—The Fauna of the Cocos-Keeling Atoll.

2. F. E. BEDDARD, M.A., F.R.S., F.Z.S.—Contributions to the Anatomy of certain Ungulata, including *Tapirus*, *Hyrax*, and *Antilocapra*.

3. Prof. Dr. E. L. TROUSSERT, C.M.Z.S.—Le Rhinocéros Blanc du Soudan.

The following communications have been received :—

1. GROUSE-DISEASE COMMISSION REPORTS :

(a) A. E. SHIPLEY, M.A., D.Sc., F.R.S. F.Z.S.—The Ectoparasites of the Grouse.

(b) A. E. SHIPLEY, M.A., D.Sc., F.R.S., P.Z.S.—The Thread-Worms (Nematoda) of the Red Grouse (*Tetrao scoticus*).

(c) A. E. SHIPLEY, M.A., D.Sc., F.R.S., F.Z.S.—The Tape-Worm (Cestoda) of the Grouse. Appendix : Parasites of Birds allied to the Grouse.

2. FRANK BALFOUR-BROWNE, M.A., F.R.S.E., F.Z.S.

The Life-History of the Agrionid Dragonfly.

Communications intended for the Scientific Meetings of the ZOOLOGICAL SOCIETY OF LONDON should be addressed to

P. CHALMERS MITCHELL,

Secretary.

3 HANOVER SQUARE, LONDON, W.

February 9th, 1909.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

February 16th, 1909.

FREDERICK GILLET, Esq., Vice-President, in the Chair.

The SECRETARY read a report on the Additions made to the Society's Menagerie during the month of January 1909.

Mr. C. TATE REGAN, M.A., F.Z.S., exhibited sketches illustrating colour-changes in some Fishes from the Bermudas in the New York Aquarium.

Mr. E. G. B. MEADE-WALDO, F.Z.S., read extracts from a letter he had received from Dr. Einar Lönnberg, C.M.Z.S., on the hunting of the Sea-Elephant on South Georgia, and called attention to the necessity of steps being taken to prevent its extermination.

Dr. F. WOOD-JONES, B.Sc., F.Z.S., presented a communication on the "Fauna of the Cocos-Keeling Atoll," and illustrated his remarks with lantern-slides. The work was based on collections made by the author during a stay of fifteen months in 1905 and 1906, and in the case of most orders was believed to be fairly complete.

Dr. Wood-Jones had been assisted by various authorities: the

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species of Reptilia were determined by Mr. G. A. Boulenger, F.R.S., V.P.Z.S.; of Lepidoptera Rhopalocera by Mr. F. A. Heron; of Lepidoptera Heterocera by Sir G. F. Hampson, Bt., F.Z.S.; of Hymenoptera by the late Col. C. T. Bingham, F.Z.S.; of Diptera by Mr. E. E. Austen, F.Z.S.; of Coleoptera by Messrs. C. O. Waterhouse, P.E.S., C. J. Gahan, F.E.S., and G. J. Arrow, F.E.S.; of Rhynchota by Mr. W. L. Distant, F.E.S.; of Neuroptera and Orthoptera by Mr. W. F. Kirby, F.L.S., F.E.S.; of Arachnida and Myriopoda by Mr. A. S. Hirst, F.Z.S.; and of Crustacea by Dr. W. T. Calman, F.Z.S.

A paper was communicated by Mr. F. E. BEDDARD, M.A., F.R.S., F.Z.S., Prosector to the Society, on "The Anatomy of certain Ungulata, including *Tapirus*, *Hyrax*, and *Antilocapra*."

Dr. E. L. TROUESSART, C.M.Z.S., presented a paper entitled "Le Rhinocéros Blanc du Soudan (*Rhinoceros sinus cottoni*)."

The next Meeting of the Society for Scientific Business will be held on Tuesday, the 2nd March, 1909, at half-past Eight o'clock P.M., when the following communications will be made:—

1. MISS MARGARET POOLE.—The Development of the Subdivisions of the Pleuro-peritoneal Cavity in Birds, illustrated by lantern-slides.

2. E. S. RUSSELL, M.A.—The Growth of the Shell of *Patella vulgata*, L.

3. FRANK BALFOUR-BROWNE, M.A., F.R.S.E., F.Z.S.—The Life-history of the Agrionid Dragonfly.

4. W. D. LANG, M.A., F.Z.S.—Growth-stages in the British Species of the Coral Genus *Parasmilia*.

The following communications have been received :—

1. GROUSE-DISEASE COMMITTEE REPORTS :

(a) A. E. SHIPLEY, M.A., D.Sc., F.R.S., F.Z.S.—The Ectoparasites of the Grouse.

(b) A. E. SHIPLEY, M.A., D.Sc., F.R.S., F.Z.S.—The Thread-Worms (Nematoda) of the Red Grouse (*Tetrao scoticus*).

(c) A. E. SHIPLEY, M.A., D.Sc., F.R.S., F.Z.S.—The Tape-Worms (Cestoda) of the Grouse. Appendix: Parasites of Birds allied to the Grouse.

2. W. P. PYCRAFT, F.Z.S., A.L.S.—On a Fossil Bird from the Lower Pliocene.

Communications intended for the Scientific Meetings of the ZOOLOGICAL SOCIETY OF LONDON should be addressed to

P. CHALMERS MITCHELL,
Secretary.

3 HANOVER SQUARE, LONDON, W.
February 23rd, 1909.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

March 2nd, 1909.

G. A. BOULENGER, Esq., F.R.S., Vice-President, in the Chair.

MR. R. H. BURNE, F.Z.S., exhibited specimens of elastic mechanisms in Fishes and a Snake which had been prepared for the Museum of the Royal College of Surgeons.

DR. R. F. SCHARFF, B.Sc., F.Z.S., exhibited a number of Reindeer bones and antlers, obtained from Irish caves, which displayed marks showing that they had been gnawed by different kinds of animals, probably in some cases by Rodents.

MR. R. I. POCOCK, F.L.S., F.Z.S., exhibited the skulls of some Leopards, and called attention to the differences in skulls from Africa and India and to the evidence afforded by them as to the existence of a small and large type of leopard in Africa.

MISS MARGARET POOLE read a paper on "The Development of the Subdivisions of the Pleuro-peritoneal Cavity in Birds," communicated by Prof. G. C. BOURNE, D.Sc., F.Z.S., and illustrated her remarks with lantern-slides.

A paper was received from Mr. E. S. RUSSELL, M.A., entitled "The Growth of the Shell of *Patella vulgata* L.," communicated

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by Prof. J. ARTHUR THOMSON, F.Z.S., of which the following is a summary:—

The breeding-season of this limpet extends from July to January. Sexual maturity is reached at a length of 20–25 mm. An average size for a limpet of the last season's brood in January or February is 10 mm.; at the end of the first year it may be 29 mm. Probable sizes at the end of the second and subsequent years are 38, 44, 48, 53 mm. Shells over 50 mm. may be considerably more than five years old.

Sexual maturity is reached in the first year and when the limpet is only half-grown. The rate of growth decreases with age and maturity, and is slower during the colder months of the year. Considerable changes take place in the ratios of the shells' dimensions during growth, being probably in large part the expression of "laws of growth" and not due to natural selection.

Mr. FRANK BALFOUR-BROWNE, M.A., F.R.S.E., F.Z.S., presented a paper on "The Life-history of the Agrionid Dragonfly."

Mr. C. DAVIES SHERBORN, F.Z.S., communicated a paper by Mr. W. D. LANG, M.A., F.Z.S., entitled "Growth-stages in the British Species of the Coral Genus *Parasmilia*."

The next Meeting of the Society for Scientific Business will be held on Tuesday, the 16th March, 1909, at half-past Eight o'clock P.M., when the following communications will be made:—

1. GROUSE-DISEASE COMMITTEE REPORTS:

(a) A. E. SHIPLEY, M.A., D.Sc., F.R.S., F.Z.S.—The Ectoparasites of the Grouse.

(b) A. E. SHIPLEY, M.A., D.Sc., F.R.S., F.Z.S.—The Thread-Worms (Nematoda) of the Red Grouse (*Tetrao scoticus*).

(c) A. E. SHIPLEY, M.A., D.Sc., F.R.S., F.Z.S.—The Tape-Worms (Cestoda) of the Grouse. Appendix: Parasites of Birds allied to the Grouse.

2. W. P. PYCRAFT, F.Z.S., A.L.S.—On a Fossil Bird from the Lower Pliocene.

3. OLDFIELD THOMAS, F.R.S., F.Z.S., and R. C. WROUGHTON, F.Z.S.—On a Collection of Mammals from Western Java, presented to the National Museum by Mr. W. E. Balston.

The following communications have been received :—

1. Miss MURIEL ROBERTSON.—Notes on an Ichthyosporidian causing a Fatal Disease in Sea-Trout.

2. C. TATE REGAN, M.A., F.Z.S.—A Collection of Fishes made by Dr. C. W. Andrews, F.R.S., F.Z.S., at Christmas Island.

Communications intended for the Scientific Meetings of the ZOOLOGICAL SOCIETY OF LONDON should be addressed to

P. CHALMERS MITCHELL,

Secretary.

3 HANOVER SQUARE, LONDON, W.

March 9th, 1909.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

March 16th, 1909.

FREDERICK GILLETT, Esq., Vice-President, in the Chair.

The SECRETARY read a report on the Additions made to the Society's Menagerie during the month of February 1909.

The SECRETARY exhibited, on behalf of Mr. E. C. CHUBB, F.Z.S., the skins and skulls of two foetal lions which had been presented to the Rhodesia Museum, Bulawayo, by Mr. A. Giese. They had been taken from a lioness which Mr. Giese shot last November at Deka, about 50 miles south of the Victoria Falls.

These fetuses showed very little pattern compared to that of newly born cubs; the black markings in each example of the former consisting only of a fairly well-defined median dorsal line, a mottling on the head, some distinct spots on the outer sides of the limbs, and a suspicion of rings on the tip of the tail.

The SECRETARY exhibited a photograph of a young American Tapir, and called attention to the remarkable resemblance between that and the young Malayan Tapir, a photograph of which was reproduced in the Society's 'Proceedings,' 1908, p. 786. The longitudinal light stripes on the flanks of the body, the spots on the legs, and the white tips to the ears were present in both.

The SECRETARY called attention to an interesting paper by C. ONELLI in the 'Revista del Jardin Zoologico de Buenos Aires,' 1908, p. 207, in which the author called attention to a general correspondence between the number of vertebræ and the number of stripes or rows of spots in many mammals.

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The SECRETARY exhibited a photograph of a small herd of Mountain Zebras (*Equus zebra*) in the possession of a dealer at Port Elizabeth, South Africa.

The SECRETARY also exhibited a photograph of a female Giraffe captured in the West Soudan, east of Timbuctoo, and showing a general resemblance with *Giraffa camelopardalis typica*.

Dr. F. A. BATHER, M.A., F.Z.S., exhibited a fossil Echinoid, *Scutellina patella*, from the Eocene? (Barwonian) of Nelson, Glenelg River, Victoria, Australia, showing a marsupium for the young, as described by T. S. Hall (Proc. Roy. Soc. Victoria, n. s. xx, p. 140, 1908).

Dr. A. E. SHIPLEY, M.A., F.R.S., F.Z.S., communicated the following Reports of the Grouse Disease Committee:—(a) The Ectoparasites of the Grouse; (b) The Thread-Worms (Nematoda) of the Red Grouse (*Tetrao scoticus*); (c) The Tape-Worms (Cestoda) of the Grouse.—Appendix: Parasites of Birds allied to the Grouse. He gave a general description of the work of the Committee, and explained the results of the examination of the parasites of the Grouse, exhibiting drawings and specimens to illustrate his remarks.

Mr. W. P. PYCRAFT, F.Z.S., A.L.S., presented an account of the fossilized remains of a small Passerine Bird, from the Lower Pliocene of Gabbro, near Leghorn, which most nearly resembled those of the living species known as Berthelot's Pipit (*Anthus bertheloti*).

A paper was read by Messrs. OLDFIELD THOMAS, F.R.S., F.Z.S., and R. C. WROUGHTON, F.Z.S., "On a Collection of Mammals from Western Java, presented to the National Museum by Mr. W. E. Balston."

The Island of Java had been almost entirely neglected during the last 60 years, while it had been one of the most prolific sources of early described species, and in consequence workers had been much embarrassed for want of modern specimens representing these early species for comparison with their allies elsewhere. Now, thanks to the generosity of Mr. Balston, a very fine collection had been made in the island by Mr. G. C. Shortridge, and presented to the National Museum. It consisted in all of over 1500 specimens, belonging to 74 species, of which six were new.

Of these latter, besides the previously described *Murina balstoni*, the following were most worthy of mention:—

RHINOLOPHUS CANUTI, sp. n.

Allied *R. creaghi*, but with a low connecting process between the sella and the posterior lancet, on which latter there is a prominent tuft of hair.

Forearm 50 mm. *Type*. B.M. No. 9.1.5.183.

ROUSETTUS SHORTRIDGEE, sp. n.

Allied to *R. leschenaulti*, but considerably larger and with much larger teeth.

Forearm 94 mm.; greatest length of skull 42 mm. *Type*. No. 9.1.5.67.

LARIA INSIGNIS JAVANA, subsp. n.

Larger, darker in colour and with larger teeth than true *insignis*.

Hind foot 47 mm.; greatest length of skull 53 mm. *Type*. No. 9.1.5.718.

CHIROPDOMYS ANNA, sp. n.

Near *C. gliroides*, but with smaller skull and teeth.

Skull length 24 mm.; molar series 3.8 mm. *Type*. No. 9.1.5.757.

The next Meeting of the Society for Scientific Business will be held on Tuesday, the 6th April, 1909, at half-past Eight o'clock P.M., when the following communications will be made:—

1. MISS MURIEL ROBERTSON.—Notes on an Ichthyosporidian causing a Fatal Disease in Sea-Trout.

2. C. TATE REGAN, M.A., F.Z.S.—A Collection of Fishes made by Dr. C. W. Andrews, F.R.S., F.Z.S., at Christmas Island.

3. R. I. POCKOCK, F.L.S., F.Z.S.—Description of a new Form of Ratel (*Mellivora*) from Sierra Leone, with Notes upon the described African Forms of this Genus.

4. HAMILTON H. DRUCE, F.L.S., F.Z.S.—On some New and Little-known *Hesperidae* from Tropical West Africa.

The following communications have been received:—

1. T. ALGERNON CHAPMAN, M.D., F.Z.S., F.E.S.—A Review of the Species of *Celastrina* (Tutt), (*Lycenopsis*, Felder), (*Cyaniris*, auct.), on examination of the male ancillary appendages.

2. F. E. BEDDARD, M.A., F.R.S., F.Z.S.—On some Points in the Structure of *Galidia elegans*, and on the Postcaval Vein in Carnivora.

Communications intended for the Scientific Meetings of the ZOOLOGICAL SOCIETY OF LONDON should be addressed to

P. CHALMERS MITCHELL,

Secretary.

3 HANOVER SQUARE, LONDON, W.

March 23rd, 1909.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

April 6th, 1909.

FREDERICK GILLET, Esq., Vice-President, in the Chair.

The SECRETARY exhibited, on behalf of Mr. GEORGE JENNISON, some fertilized eggs from a pair of Seba Pythons in the Belle Vue Zoological Gardens, Manchester.

Dr. R. T. LEIPER, F.Z.S., exhibited a greatly distorted Elephant's tusk from the Congo, and a malformed canine tooth of a Hippopotamus from Uganda, the conditions most probably originating from mechanical injury.

Mr. E. T. NEWTON, F.R.S., F.Z.S., exhibited a metatarsal bone of an Ox, showing in a remarkable manner the marks of gnawing by rodents, possibly Squirrels, Rats, or Mice, which he had found in the woods near Cromer.

Mr. R. I. POCKOCK, F.L.S., F.Z.S., communicated a paper entitled "Description of a new Form of Ratel (*Mellivora*) from Sierra Leone, with Notes upon the described African Forms of this Genus."

Miss MURIEL ROBERTSON read a paper, communicated by Prof. E. A. MINCHIN, M.A., V.P.Z.S., "On an Ichthyosporidian causing a Fatal Disease in Sea-Trout."

Mr. C. TATE REGAN, M.A., F.Z.S., read a paper on a small series of fishes from Christmas Island, collected by Dr. C. W. Andrews, F.R.S., F.Z.S. Seven new species were described, comprising five Blennies, a *Pampeneus*, and a *Cirrhit*. In connection

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with the last-named it was pointed out that the Cirrhitidæ, as defined and limited by Dr. Günther, with the addition of *Haplodactylus*, form a very natural family.

MR. HAMILTON H. DRUCE, F.L.S., F.Z.S., read a short paper "On some New and Little-known *Hesperidæ* from Tropical West Africa," which contained remarks on, and descriptions of, some new forms of these Butterflies lately obtained by Mr. G. L. Bates, F.Z.S., on the Ja River, Cameroons, and others from Nigeria. New species of the genera *Abantis*, *Acleros*, *Gorgyra*, *Parnara*, and *Ceratrichia* were described.

The next Meeting of the Society for Scientific Business will be held on Tuesday, the 27th April, 1909, at half-past Eight o'clock P.M., when the following communications will be made:—

1. DR. T. A. CHAPMAN, F.Z.S.—A Review of the Species of the Lepidopteran Genus *Lyccænopsis* Feld. (*Cyaniris* auct. nec Dalm.) on examination of the Male Ancillary Appendages.

2. F. E. BEDDARD, M.A., F.R.S., F.Z.S.—On some Points in the Structure of *Galidia elegans*, and on the Postcaval Vein in Carnivora.

3. DR. R. W. SHUFELDT, C.M.Z.S.—On the Comparative Osteology of the Passerine Bird *Arachnothera magna*.

Communications intended for the Scientific Meetings of the ZOOLOGICAL SOCIETY OF LONDON should be addressed to

P. CHALMERS MITCHELL,
Secretary.

3 HANOVER SQUARE, LONDON, W.

April 13th, 1909.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

April 27th, 1909.

Prof. E. A. MINCHIN, M.A., Vice-President,
in the Chair.

The SECRETARY read a Report on the additions that had been made to the Society's Menagerie during the month of March 1909.

Mr. H. F. McSHANE exhibited a series of lantern-slides of animals living in the Society's Gardens.

Prof. E. A. MINCHIN, M.A., V.P.Z.S., exhibited specimens of a Tick which causes an African relapsing fever in man.

Mr. R. H. BURNE, F.Z.S., exhibited a series of specimens from the Museum of the Royal College of Surgeons, showing (1) the different mechanisms for the movement of the nictitating membrane, (2) the coarse anatomy of the tapetum lucidum, (3) the organ for elevating the eyes in the Plaice.

Mr. R. I. Pocock, F.L.S., F.Z.S., exhibited photographs of the two races of Burchell's and Wahlberg's Quagga recently imported from Zululand by Herr Reiche.

A paper was presented by Dr. T. A. CHAPMAN, F.Z.S., entitled "A Review of the Species of the Lepidopteran Genus *Lycænopsis* Feld. (*Cyaniris* auct. nec Dalm.) on examination of the Male Ancillary Appendages."

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Mr. F. E. BEDDARD, M.A., F.R.S., F.Z.S., read two communications: "On some Points in the Structure of *Galidia elegans*, and on the Postcaval Vein in Carnivora," and "On the Postcaval Vein and its Branches in certain Mammals."

A paper was received from Dr. R. W. SHUFELDT, C.M.Z.S., "On the Comparative Osteology of the Passerine Bird *Arachnothera magna*," the communication being based on material supplied from the Prosectorium of the Society.

The next Meeting of the Society for Scientific Business will be held on Tuesday, the 11th May, 1909, at half-past Eight o'clock P.M., when the following communications will be made:—

1. Prof. WM. RIDGEWAY, M.A.—

- (a) On hitherto unrecorded Specimens of *Equus quagga*.
- (b) Differentiation of the Three Species of Zebras.
- (c) On a Portion of a Fossil Jaw of one of the Equidæ.

2. R. LYDEKKER.—On a new Race of Deer from Sze-chuen.

3. E. C. CHUBB, F.Z.S.—The Batrachians and Reptiles of Matabeleland.

Communications intended for the Scientific Meetings of the ZOOLOGICAL SOCIETY OF LONDON should be addressed to

P. CHALMERS MITCHELL,

Secretary.

3 HANOVER SQUARE, LONDON, W.

May 4th, 1909.

THE ZOOLOGICAL SOCIETY OF LONDON.

THIS Society was founded in 1826 by Sir STAMFORD RAFFLES, Mr. J. SABINE, Mr. N. A. VIGORS, and other eminent Naturalists, for the advancement of Zoology and Animal Physiology, and for the introduction of new and curious subjects of the Animal Kingdom, and was incorporated by Royal Charter in 1829.

COUNCIL.

HIS GRACE THE DUKE OF BEDFORD, K.G., *President.*

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M.A.

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A. SMITH WOODWARD, Esq., LL.D.
F.R.S., *Vice-President.*

The Society consists of Fellows, and Honorary, Foreign, and Corresponding Members, elected according to the By-Laws. It carries out the objects of its foundation by means of the collection of living animals at Regent's Park, by its Library at 3, Hanover Square, W., and by its scientific publications.

The Office of the Society (3, Hanover Square), where all communications should be sent, addressed to "The Secretary," is open from Ten till Five, except on Saturdays, when it closes at Two P.M.

The Library, under the superintendence of Mr. F. H. Waterhouse, is open daily at the above hours, except in September.

The Meetings of the Society for General Business are held at the Office on the third Wednesday in every month of the year, except in September and October, at Five P.M. Commencing on January 20th, 1909, these Meetings will be held on the third Wednesday of the month at 5 P.M.

The Meetings for Scientific Business are held at the Office twice a month on Tuesdays, except in July, August, September, and October, at half-past Eight o'clock P.M.

The Anniversary Meeting is held on the 29th. of April, or the nearest convenient day, at Four P.M.

The Gardens in the Regent's Park are open daily from Nine o'clock until Sunset. Mr. R. I. Pocock, F.L.S., is the resident Superintendent and Curator of Mammals and Reptiles. Mr. D. Seth-Smith is Curator of Birds and Inspector of Works. The Prosectorium for Anatomical and Pathological work at the Gardens is under the charge of Mr. Frank E. Beddard, M.A., F.R.S., Prosector, assisted by Mr. H. G. Plimmer, M.R.C.S., Pathologist to the Society.

TERMS FOR THE ADMISSION OF FELLOWS.

FELLOWS pay an Admission Fee of £5, and an annual Contribution of £3, due on the 1st. of January, and payable in advance, or a Composition of £45 in lieu thereof; the whole payment, including the Admission Fee, being £50.

No person can become a FELLOW until the Admission Fee and First Annual Subscription have been paid, or the annual payments have been compounded for.

FELLOWS elected after the 31st. of August are not liable for the Subscription for the year in which they are elected.

PRIVILEGES OF FELLOWS.

FELLOWS have Personal Admission to the Gardens with Two Companions daily, upon signing their names in the book at the entrance gate.

The WIFE or HUSBAND of a FELLOW can exercise these privileges in the absence of the Fellow.

Every FELLOW is entitled to receive annually 60 undated Green Cards, and, when no specific instructions are received, the supply will be sent in this form. If preferred, however, 20 Green Cards may be exchanged for a book containing 2 Orders for each Saturday* throughout the year. A similar book of Sunday Orders may also be obtained in lieu of 20 Green Cards. A Green Card may also be exchanged for 2 Buff Cards for the use of Children under 12 years of age.

It is particularly requested that Fellows *will sign every Ticket* before it goes out of their possession. Unsigned Tickets are not available.

Green and Buff Tickets may be used on any day and in any year, but in no case can two Children be admitted with one Adult Ticket, or an Adult be admitted with two Children's Tickets.

The annual supply of Tickets will be sent to each FELLOW on the 1st. of January in every year, upon filling up and returning the form of Standing Order supplied to Fellows.

FELLOWS are not allowed to pass in friends on their written Order or on presentation of their Visiting Cards.

FELLOWS are exempt from payment of the fee for Painting, Sketching, and Photographing in the Society's Gardens.

FELLOWS have the privilege of receiving the Society's ordinary Publications issued during the year upon payment of the additional Subscription of One Guinea. This Subscription is due upon the 1st. of January, and must be paid before the day of the Anniversary Meeting, after which the privilege lapses. FELLOWS are likewise entitled to purchase these Publications at 25 per cent. less than the price charged to the public. A further reduction of 25 per cent. is also made upon all purchases of Publications issued prior to 1881, if above the value of Five Pounds.

FELLOWS also have the privilege of subscribing to the Annual Volume of 'The Zoological Record,' which gives a list of the Works and Publications relating to Zoology in each year, for the sum of

* The Saturday Orders are not available if the Fellow introduces friends personally on that day.

One Pound Ten Shillings. Separate divisions of volumes 39 to 42 can also be supplied. Full particulars of these publications can be had on application to the Secretary.

FELLOWS may obtain a TRANSFERABLE IVORY TICKET admitting two persons, available throughout the whole period of Fellowship, on payment of Ten Pounds in one sum. A second similar ticket may be obtained on payment of a further sum of Twenty Pounds.

Any FELLOW who intends to be absent from the United Kingdom during the space of one year or more, may, upon giving to the Secretary notice in *writing*, have his or her name placed upon the "dormant list," and will be thereupon exempt from the payment of the annual contribution during such absence.

Any FELLOW, having paid all fees due to the Society, is at liberty to withdraw his or her name upon giving notice in *writing* to the Secretary.

Ladies or Gentlemen wishing to become Fellows of the Society are requested to communicate with the undersigned.

P. CHALMERS MITCHELL,

Secretary.

3 Hanover Square, London, W.,
August 1st, 1909.

MEETINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON
FOR
SCIENTIFIC BUSINESS.
(AT 3 HANOVER SQUARE, W.)

1909.

TUESDAY, NOVEMBER	9
"	23
" DECEMBER	14

*The Chair will be taken at half-past Eight o'clock in the Evening
precisely.*

LIST OF THE PUBLICATIONS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.

THE scientific publications of the Zoological Society of London are of two kinds—"Proceedings," published in an octavo form, and "Transactions," in quarto.

According to the present arrangements, the "Proceedings" contain not only notices of all business transacted at the scientific meetings, but also all the papers read at such meetings and recommended to be published in the "Proceedings" by the Committee of Publication. A large number of coloured plates and engravings are issued in the volumes of the "Proceedings," to illustrate the new or otherwise remarkable species of animals described therein. Amongst such illustrations, figures of the new or rare species acquired in a living state for the Society's Gardens are often given.

The "Proceedings" for each year are issued in four parts, on the first of the months of June, August, October, and April, the part published in April completing the volume for the last half of the preceding year. From January 1901 they have been issued as two half-yearly volumes.

The "Transactions" contain such of the more important communications made to the scientific meetings of the Society as, on account of the nature of the plates required to illustrate them, are better adapted for publication in the quarto form. They are issued at irregular intervals.

Fellows and Corresponding Members, upon payment of a Subscription of One Guinea *before* the day of the Anniversary Meeting in each year, are entitled to receive the Society's Publications for the year. They are likewise entitled to purchase the Publications of the Society at 25 per cent. less than the price charged for them to the Public. A further reduction of 25 per cent. is made upon purchases of Publications issued prior to 1881, if they exceed the value of five pounds.

Fellows also have the privilege of subscribing to the Annual Volume of the Zoological Record for a sum of 30s. (which includes cost of delivery), payable on the 1st. of July in each year; but this privilege is forfeited unless the subscription be paid *before* the 1st. of December following.

The following is a complete list of the publications of the Society already issued.

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"	X., " 95 "	(1877-79)	10 0 3	13 7 0
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" XVI., " 38 " ..	(1901-1903) ..	5 8 0	7 4 0	
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" XVIII., Pt. 1 " 9 " ..	(Aug. 1907) ..	0 15 0	1 0 0	
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P. CHALMERS MITCHELL,

Secretary.

3, Hanover Square, London, W.,
August 1st, 1909.

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ZOOLOGICAL SOCIETY OF LONDON.

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THE object of the ZOOLOGICAL RECORD is to give, by means of an annual Volume, complete lists of the Works and Publications relating to Zoology in all its branches that have appeared during the year preceding the issue of the Volume, together with full information as to the points they deal with, arranged in such a manner as to serve as an Index to the literature of Zoology in all parts of the globe, and thus to form a repertory that will retain its value for the Student in future years.

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INDEX ZOOLOGICUS. An alphabetical list of names of genera and subgenera proposed for use in Zoology, as recorded in the 'Zoological Record,' 1880-1900; together with other names not included in the 'Nomenclator Zoologicus' of S. H. Scudder. Compiled (for the Zoological Society of London) by CHARLES OWEN WATERHOUSE and edited by DAVID SHARP, Editor of the 'Zoological Record.' London, 1902. Price to Fellows, 18s.; price to the public, 20s., or if sold with a set, 10s.

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P. CHALMERS MITCHELL,
Secretary.

3 HANOVER SQUARE, LONDON, W.
August 1st, 1909.

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NOTICE.

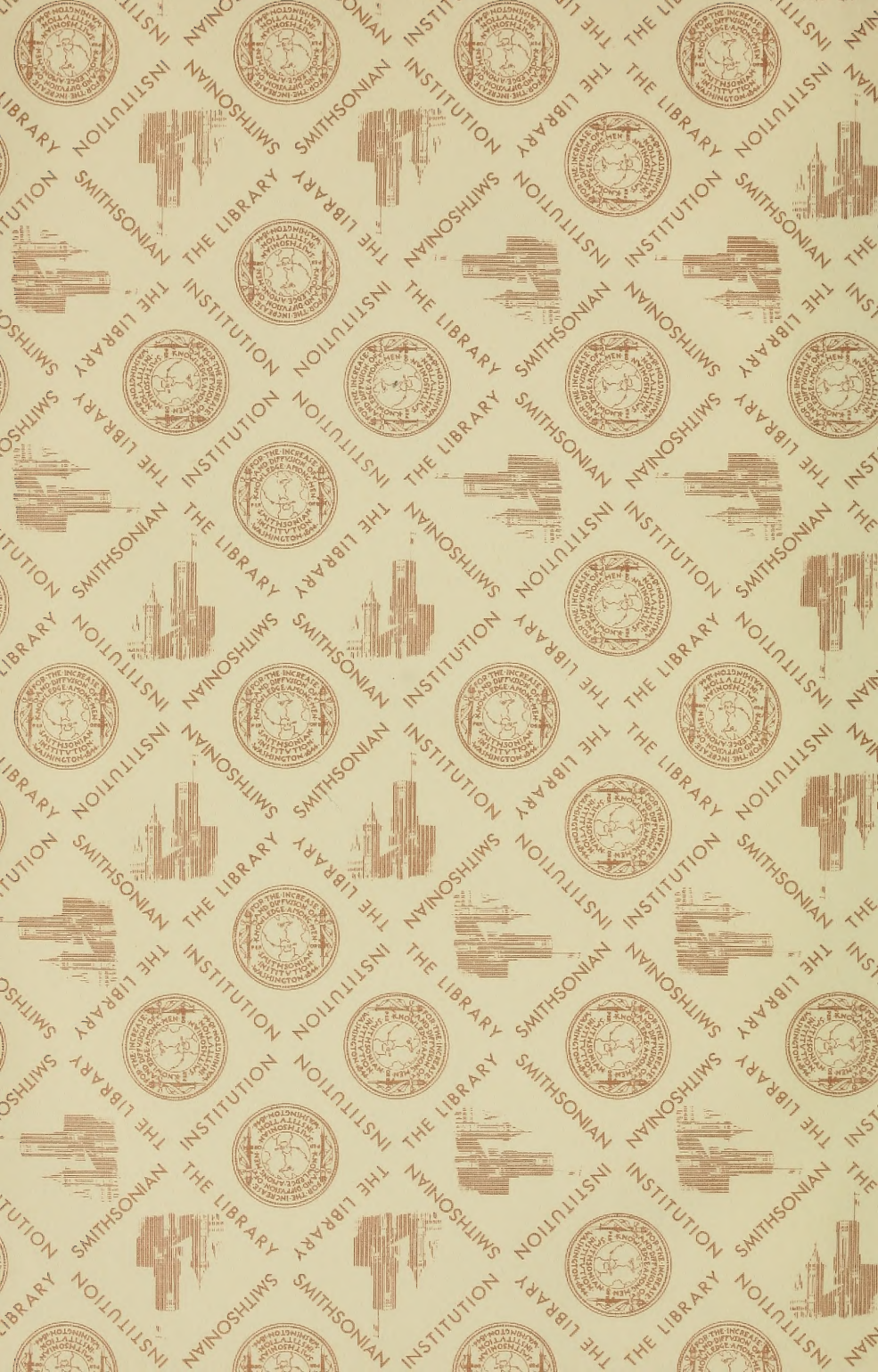
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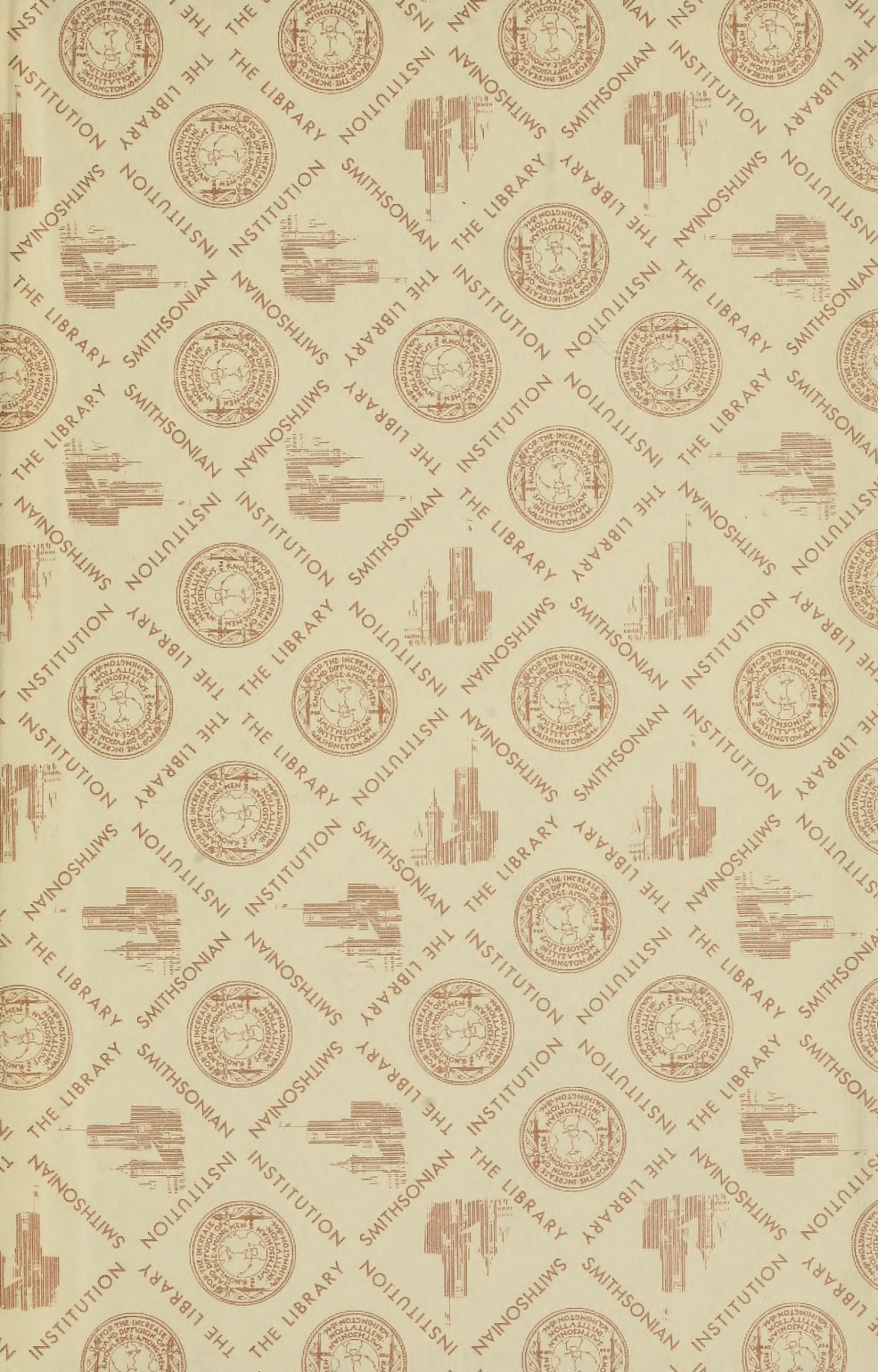
Papers read in January and February, issued in June.

"	"	March and April,	"	"	August.
"	"	May and June,	"	"	October.
"	"	November and December,	"	"	April.

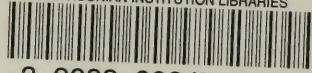
'Proceedings,' 1909, pp. 1-200, were published on May 24th, 1909.

The Abstracts of the papers read at the Scientific Meetings in
March and April are contained in this Part.





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